A study on bicycle and public transportation synergy based on a cross-analysis between Europe and Japan

A doctoral dissertation presented by

MARTIAL Léo

Submitted to

Yokohama National University
Graduate School of Urban Innovation
Institute of Urban Innovation

Under the academic supervision of

Professor NAKAMURA Fumihiko

March 2021

Composition of the final selection board

Professor NAKAMURA Fumihiko
Professor NAKAMURA Yoshiyuki
Professor MATSUYUKI Mihoko
Professor HOSODA Akira
Associate Professor TANAKA Shinji

Abstract

The search for more sustainable mobility is now a shared concern among the leaders of major European and Japanese cities, who must reduce the pressure of transportation on space, improve the quality of life and the environment by maintaining their capacity for development and preserving or improving their social cohesion. This quest for sustainability takes place in a historical, geographic and cultural context that predetermines the state of mobility and its evolution in the region. The first chapter is devoted to the history of the bicycle, and the second to the evolution of its relationship with public transportation.

The means of moving towards sustainability may be based on technological progress, urban planning, system pricing and changes in the use of modes. Transfers from individual modes to public transport are generally considered desirable, and the development of intermodal transport is one of the conditions for this development, which is the subject of chapter 3. This study distinguishes between rail and bus for public transport and between bicycle and car for individual modes. It considers the prospects for modal shift and the potential role of intermodality. These prospects depend on three types of costs: the so-called external costs, which motivate the need for greater sustainability; user costs, which largely determine user behaviour; and system investment and operating costs, often a large part of which is financed by public authorities and taxes. The theoretical characterization, modelling and empirical evaluation of these costs are the subject of the fourth chapter. Comparison of the costs per passenger-km between individual and collective modes shows that none of the three cost items can be better than the others, and that the differences depend moreover on the type of trip (length, origin-destination, etc.).

The fifth and final chapter is more prospective in nature. On the one hand, it presents the regional and transport development plans adopted by regional authorities. It also explores the potential for moving towards more sustainable mobility, based on comparisons between different regions and the cost assessments made in the fourth chapter. Two important policies are explored: parking policies and public transport pricing policies. The work presented in this thesis aims to contribute to the development of this travel cost evaluation model and a diagnostic method that will make it possible to propose visions of transportation within the framework of sustainable development and to orient travel policies towards greater sustainability and intermodality between cycling and public transportation in Europe and Japan, as well as around the world.

Keywords: *mobility, bicycle travel, intermodality, bicycle paths, bicycle roads, bicycle parking, bicycle sharing, bicycle policies, bicycle culture, travel cost*

Summary

Introduction

We will first present the general context from the societal and scientific point of view of our thesis. We will then describe the positioning of the problematic of this research and the methodological framework of this research. Finally, we will present our empirical approach.

General context

The urban population is growing rapidly, especially in emerging countries where urban areas are developing at high speed. This phenomenon is generating a sharp increase in urban mobility. This trend towards increased mobility can also lead to growing problems of network saturation, with notable socio-economic and environmental consequences, such as traffic congestion, local air pollution and contribution to the greenhouse effect, extension of travel distances, insecurity, etc.

Since the Kyoto conference in 1997, populations and States have gradually become aware that CO_2 emissions linked to the resulting greenhouse effect constitute a major risk not only environmentally, but also economically and socially. With the increase in greenhouse gases and global warming, behaviours and lifestyles are being targeted.

Road transport is one of the main contributors to this pollution and transport policymakers, professionals, and researchers are increasingly focusing their thinking on environmental issues and the need to reduce the use of motorized vehicles, particularly in urban areas, in order to create more pleasant and sustainable cities.

Encouraging the diversified use of transport modes, and in particular intermodality, is a favourable way to reduce the level of motor vehicle use to protect our health, reduce infrastructure costs and make roads more pleasant for pedestrians and cyclists. However, individual vehicle use continues to grow internationally and is not declining in most developed countries. The change in behaviour recommended by various studies seems difficult to achieve so far, and the consequences of the growth in motor vehicle use are still relatively uncontrolled.

Intermodality (Intermodal transportation is a feature of a transportation system that allows at least two different modes of transportation to be integrated in the same door-to-door trip. It is also a quality indicator of the level of integration between different modes of transportation. The fundamental theory of intermodality means more integration and complementarity between modes by providing the means for more efficient transportation use), a term that has been in vogue in recent years and is now in many reports, speeches, and major projects. The concept is not recent (ISTEA (1991), GART-ADEME (1997), European Commission (2001), INTERMODA Project (2002), Eurostat and ECMT (2004)). Problems of articulation between modes of transport and coherence of supply are as old as transport itself. However, intermodality, so often invoked, is still insufficiently implemented in practice.

According to the ECMT report, the strict definition of intermodal transport is primarily concerned only with freight transport. However, this definition may also apply to passenger transport. Indeed, the concept of intermodality is broad. Intermodal policy can be said to exist when there is an integrated approach to the development and management of different networks, such as park-and-ride facilities between private vehicles (PV) and public transport (PT).

A much more specific approach is also possible, with the implementation of specific devices to facilitate the successive use of two (or more) means of transport during the same journey, with the aim of drawing on the qualities of each of the means at one of the links in the chain. It is in particular this last meaning of the term that we will retain here.

The European Commission's White Paper published in 2001 already indicated that intermodal passenger transport is one of the directions for effective transport policies to achieve a balance in the development of road and public transport modes. Public transport, on the other hand, is by its very nature not capable of providing door-to-door service for the vast majority of inhabitants. A major obstacle to the growth of intermodal transport is generally a quality of service that is considered insufficient: sometimes long and arduous changes, potentially high costs (sometimes several modes of transport to be financed), and the planning of the individual transport needed to reach public transport subject to defined schedules.

Fostering intermodality means giving public transportation (PT) the opportunity to create, maintain or strengthen its place in the structure of our cities. It also means creating a real complementarity of transportation modes to minimize the nuisance caused by uncontrolled use of motorized vehicles and encourage a modal shift. The opportunities for implementing intermodal policies are at different territorial levels: regional travel plans, urban travel plans or State-regional plan contracts.

Scientific studies on the subject are segmented but more and more interdisciplinary and transversal research on different themes are emerging. The practicability of implementing intermodality and individual logics in modal choices remains an active field of research, necessary to provide answers to this problem of encouraging intermodality in urban spaces.

This thesis on the intermodality between bicycles and public transport was initially the subject of a literature review on the knowledge and challenges of intermodality. The aim of this research is to grasp upstream questions about the potential of intermodality in transport in different dimensions due to their socio-economic, demographic, geographical situations, modal split and mobility. This thesis focuses on an international comparison between Japan and Europe, allowing comparisons in infrastructure and policy development while analysing clear distinctions.

Problematic

Our issue is part of the debate on the potential and practicability of bicycle intermodal transport with a view to significantly reducing the use of motor vehicles in the context of sustainable development.

The qualitative description of transportation in urban areas can be profoundly different. In other words, the development of intermodal transport in these areas generally faces different challenges. Therefore, we aim first to study in depth the current mobility situation either in Japan and Europe in order to reference the respective problems of transport development and second, to outline the potential development of intermodality in these areas. All issues will be addressed within the framework of sustainable transport development.

First questioning

Since intermodality is by nature based on existing transportation networks, a study of the latter is a necessary first step. We are therefore interested here in two main issues around mobility and intermodality.

What is the evolution and current situation of cycling in Japan and Europe?

What is the current state bicycle and public transport intermodality?

Is it attractive enough today to encourage people to use public transit and at the same time reduce motor vehicle dependency in these areas?

These questions are intended to describe the strengths and weaknesses of the urban transportation system and the mobility problems encountered in Japanese and European urban areas. These answers may guide potential directions for the development of intermodality.

Second questioning

From the travellers' point of view, the first decisive factors in choosing the mode of transportation are the expenditure of time and money. The level of attraction of modes can thus be diagnosed by the private cost, which is the sum of monetary and time costs. Public expenditure and external costs must also be taken into account.

It is still uncommon to find research that converges all of these costs in the same analytical framework. Ignoring some costs may lead to a shift to a mode of transport without much coherence or sustainability. We therefore aim here to answer three questions related to the application of travel cost analysis to the search for urban mobility in the context of sustainable development.

How can travel costs allow us to distinguish the level of attraction of modes for travellers according to several urban scales? What are the links between travel costs and travellers' modal choice?

For the analysis of the sustainable development of urban transport, it is necessary to take into account the viewpoints of users, public authorities, and society as a whole through the externalities produced, and thus to establish a three-dimensional analysis. So how can we establish a diagnostic model based on all these aspects?

As a result of this three-dimensional analysis of travel costs, what direction of transportation development can we trace in future urban spaces?

Through this second series of questions we seek the main elements that can explain the structure of urban mobility and the direction of development through activity, the territory for the areas studied. We then aim to observe and compare all these elements.

Third questioning

Governments can implement transportation strategies and measures based on a travel costing model. We then propose several questions regarding the study of transportation measures.

What will be the perspective for the development of urban transport within the framework of sustainable development in the medium and long term?

How can a set of coherent measures be identified within the framework of sustainable development according to the different dimensions: environment, public financing, mobility efficiency and compatible urban development?

Also, which measures can be favourable to encourage intermodality?

In this series of questions, we aim to diagnose the relevance of measures related to sustainable development by specifying the advantages and disadvantages for these measures by activity and by territory.

Methodological framework

Following the problem definition, let's establish the main steps of the research process.

Positioning of the research
We first explore the classification of passenger trips and the typology of intermodal trips across different dimensions (socio-economic, geographic demographic, etc.).

Literature review
We then gather documentation on the definition of cycling and intermodality. The first focuses on the history of cycling in Europe and Japan, the second concerns the relationship of bicycle with public transportation, the third the definition of intermodal hubs in urban areas, the fourth the costs of intermodal trips and the fifth the influences on urban areas.

Cost analysis model
We establish a general model for the evaluation of travel costs - accounting and economic approaches - according to their typology by mode and area. We will then build a diagnostic model of the modes according to their competitiveness. Finally, we will present the private cost, the public cost and the external cost in the evaluation of travel costs for the zones studied.

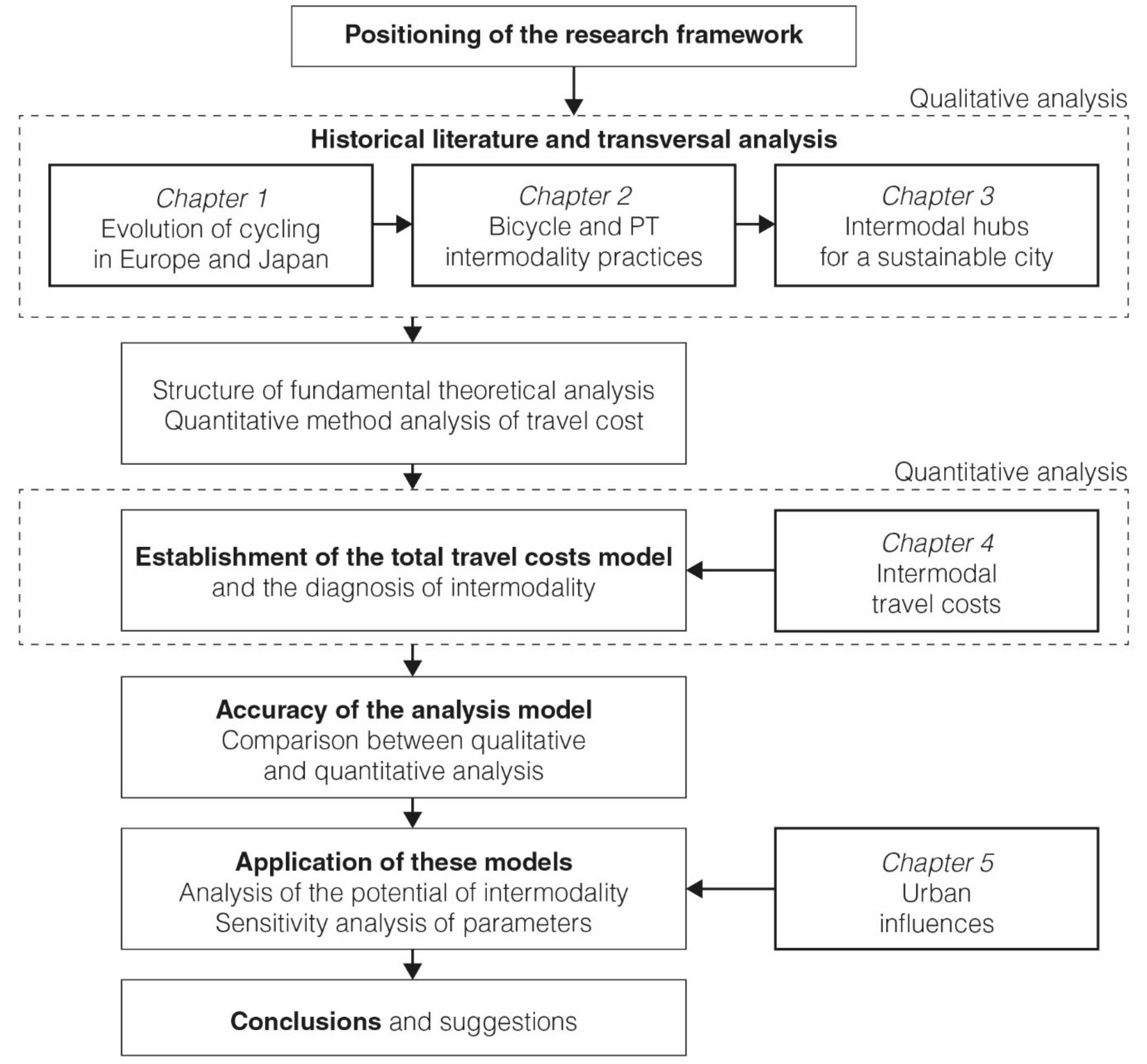
Cost comparison
Following the evaluation of travel costs by activity and mode, we propose a summary of costs according to accounting and economic approaches, then a comparison between costs and median salary.

Development prospects
Faced with the various mobility challenges, we will present the prospects for the sustainable development of urban transportation by outlining medium and long-term development paths.

Measurement diagnostic model
Following the development perspectives, we establish a measurement diagnostic model based on four perspectives: environment, public financing, mobility efficiency and compatible urban development.

Discussion and conclusion

Finally, we offer various conclusions around the analysis results and provide suggestions for further research.



Research structure

Organization of the thesis

The objective of intermodal transport is not only to reduce dependence on the use of individual motorized vehicles but also to provide all inhabitants with a suitable alternative for their daily journeys in a more pleasant and sustainable urban environment through cycling. Our thesis is divided into five chapters:

Chapter 1: The evolution of cycling in Europe and Japan

How did the velocipede compete with the horse? Why do the Dutch ride more bicycles than the French? Is the car really faster than the bicycle? What should we think about self-service bicycles, folding bicycles, electric-assisted bicycles? Is the multiplication of bicycle paths enough to revive cycling?

Tracing the history of the bicycle, from the 19th-century draisienne to the prototypes of the 21st century, and looking at its economic, cultural and social environment as well as its technical aspects, this first chapter tells the story of the bicycle in urban travel in Europe and Japan.

Indeed, while it triumphed in the 1920s and 1930s, the bicycle was driven out of European and Japanese cities in the post-war growth years, when technical and industrial modernity decreed the triumph of motorized life. From the 1970s onwards, and against all expectations, the bicycle made a gradual return to Northern Europe. But France and other countries missed this turning point, and the situation stabilized at a fairly low level in Japan.

Analysing urban travel policies across Europe, this first chapter aims to show that traffic moderation has played a decisive role in the return of the bicycle and that intermodality with public transport can be one of its main avenues for development. Indeed, the bicycle could become an indispensable means of locomotion to counter the effects of the economic and ecological crisis, without forgetting to contribute to making the city an egalitarian and convivial space.

Chapter 2: Bicycle and public transport intermodality practices

A growing number of local authorities in Europe and Japan are now implementing policies to encourage intermodality between bicycles and public transit. Far from being limited to the link between self-service bicycles and public transit, these intermodal policies take a wide variety of forms in communities with increasingly diverse profiles.

This chapter aims to provide a comprehensive inventory of actions to facilitate intermodality between these two modes of travel that are key to sustainable mobility, by focusing on the determinants of these intermodality measures that either promote or hinder their effectiveness.

This chapter thus aims to shed light on the possible choices of transit authorities wishing to invest in the development of intermodality between cycling and public transport.

Chapter 3: Intermodal hubs for a sustainable city

Multimodal transport hubs are both an object of public action and a source of innovation. n lieu of complex collective practices. Indeed, they reveal functionalities linked to the mobility of people, to forms of commercial and service activity, while at the same time fitting into the urban fabric of the territories in which they deploy their uses.

It is therefore both varied institutional players (local authorities, developers, operators, retailers, services) and multiple users (travellers, consumers, service users, local residents) who meet in this unique but polymorphous place. The real challenge for those involved in these objects is therefore to create and maintain harmony between the different functions of the exchange hubs, from their genesis to the moment of their mutation.

In view of the challenges of coherence, cohesion and articulation of these functions and uses, this chapter will focus on the elements that contribute to the unity of the exchange centre.

This chapter proposes an organized reading of the different facets of a project for a clearinghouse as well as recommendations for action. These elements are organized around reference points on the reality of mobility within the exchange clusters and the challenges they face. They highlight territorial strategies and interests to act on these objects as well as the governance and project management that result from them. Finally, they propose benchmarks in terms of dimensioning, before returning to the conditions conducive to the sustainable use, management and evolution of the hubs.

Chapter 4: Intermodal travel costs

Transfers from individual modes to public transport are generally considered desirable, and the development of intermodal transport is one of the conditions for this development. This chapter distinguishes between bus and rail in collective modes, and between bicycle, motorized two-wheelers and car in individual modes. It discusses the prospects for modal shift and the potential role of intermodality. These prospects depend on three types of costs: the so-called external costs, which motivate the need for greater sustainability; user costs, which largely determine user behaviour; and system investment and operating costs, often a large part of which is financed by public authorities and taxes. The theoretical characterization, modelling and empirical evaluation of these costs are the subject of this chapter. Comparison of the costs per passenger-km (pkm) between individual and collective modes shows that no one mode can be better than the others on all three cost items, and that the differences are moreover dependent on the type of travel.

Chapter 5: Urban influences

This chapter is more prospective in nature. It presents, on the one hand, the territorial and transport development schemes adopted by those in charge of these territories. On the other hand, it explores the potential for moving towards more sustainable mobility based on comparisons from our territories and the cost assessments carried out in the previous chapter. Two important policies are explored: parking policies and public transport pricing policies. The aim of the work presented in this thesis is therefore to contribute to the development of this travel cost evaluation model and of a diagnostic method that will make it possible to propose visions of transport in the context of sustainable development and to orient travel policies towards greater sustainability and intermodality.

Chapter 1

The evolution of cycling in Europe and Japan

Introduction, cycling and the urban travel system

In the Netherlands, Denmark and, to a lesser extent, Germany and Switzerland, bicycles are used on a daily basis: hordes of cyclists jostle each other in all weathers on the bicycle paths and thousands of bicycles pile up near central stations or around the busiest places. In other European countries such as France, the United Kingdom and Spain, the utility bicycle has virtually disappeared from the urban landscape, relegated to the status of a confidential and obsolete mode of transportation. Of course, in recent years, self-service bicycles have been reviving its appeal, and electric-assisted bicycles are enjoying some success. However, this phenomenon is especially noticeable in the centres of large cities. How do you explain such discrepancies in practice? Is it simply a cultural issue, as many people claim? Or should we see it as the ups and downs of a contrasting history of cycling in these different countries? And what role do state and city travel policies play in this?

These questions become more complicated when one discovers the disparity of situations in the same country. In France, to limit ourselves to this example, cyclists are relatively numerous only in Strasbourg and La Rochelle. They are half as numerous in Bordeaux, Rennes and Grenoble, and in many cities, they are still very rare. Clear differences also exist between the centre and the periphery, on the one hand, and between large and medium-sized cities, on the other. Can we then conclude that there is a "return to cycling as a mode of travel" (Papon, 2012) and can this return be sustainable and widespread?

Whatever one's opinion on cyclists, this return - if confirmed - would be good news. Because of its low cost, both for individuals and the community, its virtually zero impact on the environment and its very positive public health record, cycling, used massively as a mode of travel in its own right, represents a major potential contribution to the development of sustainable cities. The most edifying foreign examples are tangible proof of this. No "clean vehicle", be it a pioneering public transport system or an innovative individual motorized vehicle, will ever have such benefits, even though these solutions can be considered, in many circumstances, as useful complements.

Our work therefore has a twofold objective: on the one hand, to try to understand these differences in the practice of utility bicycles between European countries and between cities, and on the other hand, to try to identify the evolution of practices, by identifying the underlying movements of cyclical variations thanks to sufficient historical hindsight. These two aspects are obviously linked, since the differences at a given moment often result from divergent developments, the stages and causes of which must be understood. What remains to be done is to find a method for analysing the evolution of cycling mobility in urban areas. In order to do so, explanations that are a little too short should be discarded from the outset.

Modal shares of the bicycle

The simplest and most widely used indicator to measure the importance of cycling in a territory is the "modal share", which is the share of trips made by bicycle of all trips, including those made on foot. A trip is a journey made by a person using one or more modes, for a specific reason (work, study, shopping, etc.), between a different place of origin and a different place of destination. A trip using several modes is counted according to the heaviest mode: for example, a trip by bicycle and then by train is counted as a train trip. Figure 1.I.1 shows the considerable differences in cycling in different European countries and Japan.

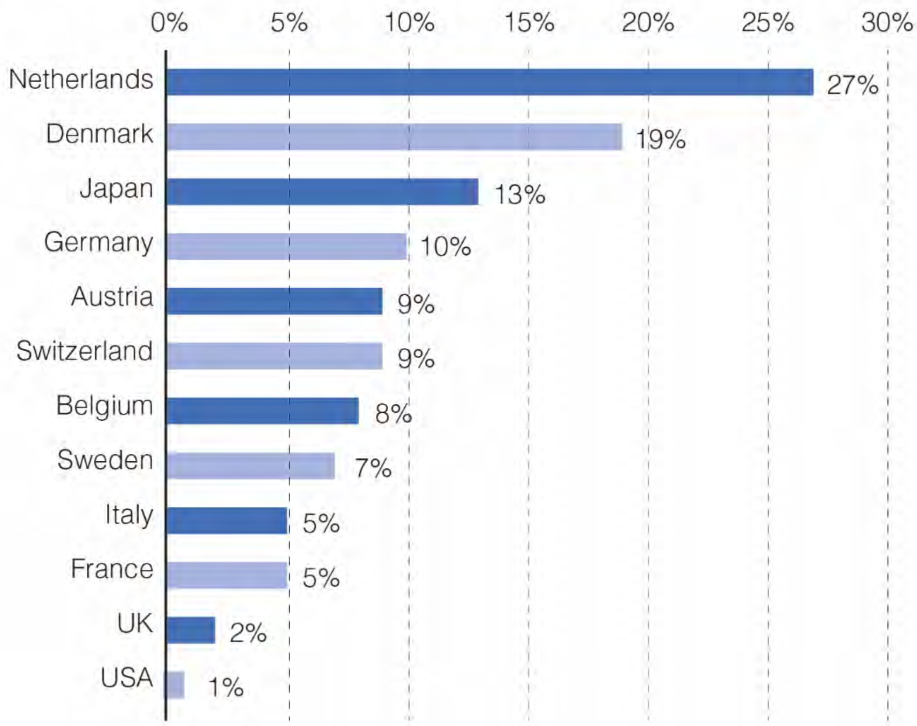


Figure 1.I.1. Modal share of cycling in Europe and Japan

Source: MLIT, 2015

When exploring pre-1970s epochs, studies of these modal shares, when available, often lack reliability. The data are limited to vehicle fleets, mix bicycles with motorized two-wheelers, or cover all traffic, not just urban travel. In addition, there are formidable difficulties of international comparison, as each country has developed its own statistical tool. Thus, the attempted comparison in Figure 1.I.1 has not been repeated to date.

For this reason, the modal shares or possession rates used in this book should be considered with caution: only major deviations and major changes are taken into account. The aim is not to be as precise as possible, but to make meaningful comparisons in order to open up hitherto neglected avenues of reflection.

National cultures, relief, climate? Getting out of the common places

Many authors consider that the low level of utility bicycle use in France is linked to the latin culture. The linguistic border would explain most of the existing gaps in Europe. In the Batave, Scandinavian and Germanic worlds, it would be normal to ride a bicycle from the cradle to the grave, whereas in Latin countries it would still be incongruous. Consider, we are told, the differences in practice depending on whether one lives in Belgian Flanders or Wallonia (13% modal share versus 1% (Cornélis et al., 2012) or in German- or French-speaking Switzerland (6% versus 2%). And, if there are so many cyclists in Strasbourg (8%), it is simply due to the city's proximity to Germany and, in particular, to Freiburg (19%).

The exceptions to this "cultural determinism" (Guidez et al., 2003) are so numerous, however, that it is difficult to believe in this explanation, which is sketchy to say the least. While Strasbourg is perhaps close to Freiburg (65 km), Mulhouse is even closer (45 km) and even more so to Basel (25 km), a city with a high level of cycling (17% modal share in the canton of Basel City). However, cycling in Mulhouse (2%) is much less developed than in Strasbourg. Similarly, although the Lille metropolitan area is very close to Belgian Flanders, particularly Kortrijk (more than 20%), bicycles are not much used there (2%) and even less so in Tourcoing (1%), which is very close to the border. And what about La Rochelle (8% modal share, as much as Strasbourg), far from any "foreign influence"?

In addition, according to European Platform on Mobility Management, there are large differences in cycling behaviour between cities within Europe, for example in Germany between Bremen (22%) and Wiesbaden (3%), in England between Cambridge (10%) and Nottingham (1%) or even in the Netherlands between Leiden (33%) and Rotterdam ("only" 16%). Also, how can we explain the case of these Italian cities where cycling is completely comparable to the most cycling cities in Northern Europe, such as Bolzano, where the modal share is 29%, Ferrara 27%, Padua 16% or Reggio Emilia 15%?

Finally, in one hundred and twenty years, the practice of bicycling has experienced enormous fluctuations, including in the countries and cities that are now the most cyclist. It is a mistake to believe that people in Amsterdam, Copenhagen or Berlin have always used bicycles on a massive scale. After the Second World War, on the contrary, cycling in these cities collapsed - the word is not too strong - before gradually recovering since the 1970s.

In short, it's not because we speak Dutch, Danish, Swedish or German that we would have a natural propensity to ride a bike in the city. If culture plays a role, it's in a much more subtle way.

Another commonplace view is that physical geography would explain much of the differences in cycling in different places. A few simple considerations quickly ruin this idea.

The lack of relief would obviously favour the Netherlands and Denmark. On that account, very flat cities such as Dunkirk or Lille should be very cycling friendly, which is far from being the case with only 2% of modal share for cycling. Conversely, fairly hilly cities like Bern or Trondheim (Norway) have much more cyclists (11% and 8% modal share respectively).

A temperate climate, particularly mild in winter, is also a priori an asset. Strasbourg, the most cycling city in France, has harsh winters and stifling summers. The same goes for very cycling cities such as Berlin, Munich or Graz... Rain, snow and ice should be formidable obstacles to regular cycling. So how can we explain that cycling is so much practiced in Northern Europe and much less in the South? Frequent winds should finally penalize cyclists. A strong headwind is as hard to face as a hill to climb and a good wind in the back almost prevents the cyclist from pedalling. Alas, the Netherlands and Denmark are also the most subjected to this hazard, as well as La Rochelle.

Geographic and physical constraints obviously play a role, but they are far from being as decisive as we intuitively think.

Generations, social classes and lifestyles

As the cultural and geographical trails, in their simplistic version, prove to be inconsistent, it is appropriate to explore the problem in greater depth, addressing the historical evolution of the utility bicycle in each country and then in each city. This approach gives more interesting results, revealing a profound evolution of uses according to time and social class.

The bicycle was originally, in the years 1860-1900, a very expensive leisure activity reserved for the bourgeoisie, then, as its purchase cost decreased, it became democratized to become, in the inter-war period, the vehicle of the working class. During the 1950s, throughout Europe, including France, workers still travelled to work on bicycles on a massive scale. The bicycle then conquered a sporty and ecological public with bicycle tourism in the 1960s and 1970s, then the cross-bike and the mountain bike in the 1980s and 1990s. In recent years, bicycles have regained a certain appeal in the centre of large cities among an educated public, keen on self-service or electric-assisted bicycles. Sociologist Philippe Gaboriau distinguishes "three ages of the bicycle in France": "bourgeois speed", "popular speed" and "ecological speed"(Gaboriau, 1991). The sociologist Philippe Gaboriau also distinguishes between "the three ages of the bicycle in France": "bourgeois speed", "popular speed" and "ecological speed". Historian Catherine Bertho Lavenir identifies "four paradigms": the age of the velocipede (1814-1880), the age of the bicycle (1880-1914), the age of the bicycle (1914-1970) and, lastly, the bicycle in the age of the automobile (since 1970) (Bertho Lavenir, 2011).

This historical approach gives pride of place to the generational dimension of the phenomenon. Older people who lived through the last war would rather have a bitter memory of the bicycle, a symbol of restrictions and impoverishment: they hardly imagine that it could become a utility vehicle again. Workers and employees who have abandoned the bicycle to gradually move to motorization - with difficulty and at a late stage for the poorest - are even less likely to consider it. And those who have experienced bicycle rides in good weather have retained a certain nostalgia for it and hardly associate the bicycle with daily use.

If we caricatured it a little, the rise of the bicycle, in its various forms, would finally be a simple fashion phenomenon linked to successive generations of cyclists who would become infatuated with the various ways of cycling. The sharp decline in utility bicycles would be linked to "modernity" and its current success would be explained today by the concern to "preserve the environment", as Northern Europeans are reputed to be more sensitive to this theme. This approach, which focuses almost exclusively on the technical evolution of the bicycle and its uses, is somewhat disconnected from reality because it strongly underestimates the context, and in particular the role of other modes of travel.

For a historical approach to cycling in the overall urban travel policy

The evolution of bicycle use, since its origins, deserves to be seen in the more general evolution of the various modes of urban travel, namely walking, public transport, motorized two-wheelers and the automobile. There are many reasons for this.

First of all, it must be kept in mind that all these modes compete in a non-extensible travel market. Since surveys measuring daily mobility have become available, it appears that city dwellers still make, on average, only three to four trips per weekday (Zahavi, 1973). Consequently, any expansion of one mode can only occur at the expense of other modes. For example, promoting car traffic almost always reduces the use of all other modes of travel. Similarly, encouraging cycling does not necessarily mean that it is at the expense of car use, but more often at the expense of walking or public transport. Conversely, an insufficient supply of public transport may be sufficient to stimulate bicycle use.

Competition between modes of travel also has an economic dimension. When financial resources decrease, the bicycle tends to become a credible solution again, in the minds of decision-makers and users alike, as its costs remain modest in terms of facilities and use. Crises have always favoured cycling. Today's crisis, which could well lead to lasting stagnation, is likely to dry up investment in motorized modes in favour of "active modes": walking and cycling.

These different modes compete with each other, but they do not compete in the same category. The fastest and most massive have a considerable advantage over the slowest and lightest, because the former threaten the security of the latter and degrade their environment through the nuisance they generate. As they have no bodywork, cyclists feel vulnerable in traffic and the fewer they are, the more insecure they are. Without a passenger compartment, cyclists are also directly subjected to the noise and pollution generated by motor vehicles.

In addition, motorized modes need a highly hierarchical, tree-like network made up of service roads, intermediate roads and major roads to take advantage of their speed, whereas non-motorized modes require a non-hierarchical but well meshed network to be able to get to the shortest route without getting too tired. As a result, the rail and road networks create major obstacles to cycling and walking because of the cut-off effect caused by major infrastructure. Cyclists find themselves confined to their neighbourhoods, no longer able to travel safely from one neighbourhood to another, which greatly reduces the appeal of cycling (Héran, 2011).

More broadly, it is not only the articulation between modes of travel that needs to be taken into account, but also their integration into urban transportation systems: the public transit system, the automobile system and the bicycle system. Each mode needs reliable and affordable vehicles (buses, streetcars, subways, suburban trains, cars and bicycles), but also high-quality facilities (corridors, railways, roads, tracks and bicycle lanes) that form a network (hence the traffic management models), varied and extensive services (parking, repairs, insurance, rentals, network maps, etc.) and common rules (driver's license, highway code, signage, etc.). If one or more of its components fail, the use of the mode is compromised. In addition, there is a need to understand how these various transportation systems work together.

In short, it is impossible to explain the evolution of cycling without placing it in the highly competitive and complex world of urban travel. In other words, the history of the utilitarian bicycle is mainly a history of its relationship to other modes of travel (hence the subtitle of this book). This systemic approach is typical of economists working on urban travel (Bonnafous, 1996). Mobility historians are not well equipped to deal with these issues. They tend to focus more naturally on the cultural and social dimensions, which, however interesting and relevant they may be, often miss an essential part of the subject. As for technical historians, they are mainly interested in the competition between technologies, this time underestimating the systemic dimension of the subject (Mom, 2003).

Concretely, to understand the evolution between two successive eras, one must try to report not a simple change of mode of travel to another, but a general modal shift, describing the shifts from each mode to all the others (Héran, 1995). And this, without forgetting demographic changes: some inhabitants leave, whether they move, become bedridden or die, while others arrive with new travel habits, whether they move in or reach the age of travel. The exercise, as we can see, is a Rubik's cube type puzzle: by distinguishing six modes, forty-two flows have to be considered (see figure 1.I.2). To complicate matters, more and more users are getting into the habit of using several modes according to the circumstances.

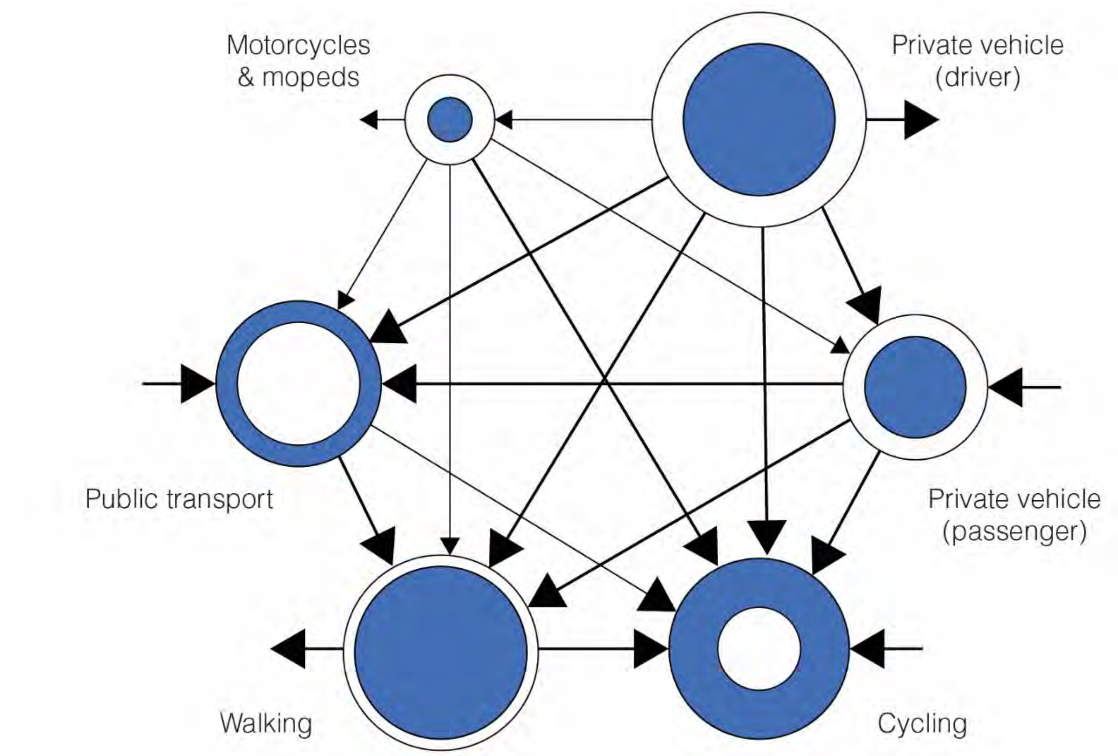


Figure 1.I.2 Principle of general modal shift between two successive eras

Source: Created by the author

Note: The white circles represent the modal share in era 1, the blue circles in era 2, for example twenty years later. The arrows between two circles represent the net modal shift. The arrows between a circle and the outside evaluate the shifts in and out of the system. The size of the circles is proportional to the volume of stocks and the size of the arrows to the volume of flows. In the case presented here, the modal share of cycling is increasing and the modal share of public transport is increasing, to the detriment of walking and, above all, of cars and motorized two-wheelers.

The constitution of cities and nations around certain privileged modes of travel

In the history of a city or a nation, particular choices, which sometimes mean little, lead authorities to embark on travel policies that favour certain modes over others, to the point of consolidating them into powerful transportation systems that become very attractive. These choices end up being taken on board by the population, which then tends to consider these modes as vectors of identification with a city or even a nation, thereby reinforcing these policies. This approach makes it possible to approach the cultural question in a renewed and much richer way (Stoffers et al., 2010).

The case of Strasbourg is interesting from this point of view. After discovering, at the end of the 1980s, the importance of its modal share of cycling, the city finally launched, in 1995, a communication campaign based on the slogan "Strasbourg, un vélo d'avance" (Strasbourg, one bike ahead), which indeed corresponds to a French reality. Today, many people in Strasbourg have integrated this particularism and find it normal to travel by bicycle. Likewise, Ferrara, in Northern Italy, has been claiming to be the "città della biciclette" since the same year, comforting the inhabitants in this way of getting around.

In the case of the Netherlands, it was even an entire people who, at the end of the 19th century, built an identity around the bicycle, which was used to rediscover the nation at a time when the country feared the powerful neighbouring Germany that had recently unified (Ebert, 2004). In the 1970s, the country returned to cycling, which was then in decline, and managed to revive it, thereby cultivating its image as the "country of the bicycle Dutch Cycling Embassy - which sells its know-how abroad as an export brand. Denmark is developing a similar approach in healthy competition. Conversely, a country like the United Kingdom has so few cyclists today that they tend to be stigmatized, considered as foreigners or even scapegoats, (Agervig et al., 2012) even though the practice is now on the rise in some cities.

This identification of the majority of the population with the use of certain modes of transport may ultimately appear to be a cultural trait specific to each city or nation. However, it conceals a whole history - often with profound changes in the actual practice of cycling - which we must try to reconstruct and which a cultural approach alone cannot explain.

Enlightening international comparisons

In order to reveal French specificities more easily, to understand why it has become incongruous to travel around town by bicycle in France, and how to draw inspiration, if necessary, from policies implemented elsewhere, the study of other countries seems indispensable.

But, as the politician Pierre Hassenteufel notes, venturing into international comparisons “presupposes first of all that one must distance oneself from two positions: the first is that of incomparability, the second is that of spontaneous comparability irreducibility of cultures” (Hassenteufel, 2005) falls into the first flaw: it would a priori be impossible for the French to ride bicycles massively, as the Dutch or the Danes do, or even more moderately, as the Germans do. However, one should not fall into the second traverse. In these emblematic countries, cycling does take on specific forms that should be understood: importing their "recipe" - often wrongly summarized by the construction of a well-meshed network of bicycle paths - is certainly not the miracle solution.

Two transnational phenomena, however, tend to homogenize urban transport systems. On the one hand, the industrial production of bicycles, streetcars and cars has rapidly become global, with similar technical standards that constrain the gauge and structure of traffic routes. On the other hand, road signs and regulations were gradually harmonized, under the impetus of the Permanent International Association of Road Congresses (PIARC) at the beginning of the 20th century. As a result, similar modes of transport operate on fairly similarly constructed, organized, and managed networks. Substantial differences remain mainly in the degree of segregation or integration of the various modes, in the division of space among modes, and in the form and hierarchy of networks. But we shall see that, even in this area, travel policies have been converging for some years.

Three countries will be studied in particular: France, of course, the Netherlands, for the exemplary nature of its policy in favour of cyclists, and Germany because its policy in this area has long remained fairly close to that of France before diverging. But we will allow ourselves incursions into other countries: Denmark, quite similar to the Netherlands, the United Kingdom, very close to the French case, or Italy, a surprising Latin country. We will mention more specifically the Scandinavian countries, Belgium, Switzerland, Austria and Spain, and sometimes even a few countries outside Europe.

Understanding the past to look to the future

The book therefore presents itself as a history of the utilitarian bicycle in Europe in the overall evolution of urban mobility. The project may seem, quite rightly, too ambitious. But it is above all a matter of bringing together a few elements of a European history of urban travel that is too often segmented by country, period or mode. Our work is essentially based on the existing academic literature, which is certainly not very extensive and too compartmentalized, but which is already significant (more than 400 references have been mobilized). Some Europeans and Japanese journals have also been systematically consulted. On many of the aspects addressed, much more in-depth investigations would be necessary. For example, it would be advisable to consult more systematically specialized ancient journals, to search the historical libraries of the countries studied, to work on the comparability of statistics from one country to another, and to better understand the socio-historical contexts of each country: an enormous task, beyond our capacities, which qualified historians will perhaps be eager to take up with greater method.

We have chosen a plan by major historical periods, rather than by country or theme, in order to best reconcile national and analytical approaches. The first section briefly reviews the origins of the bicycle when, at the end of the 19th century, it was considered a symbol of modernity. Section 2 recounts the democratization of the bicycle from the beginning of the 20th century to the 1930s, and the first threats to its development linked to the beginnings of the adaptation of cities to the automobile. Section 3 recalls how, in the post-war period, cycling rapidly declined throughout Europe, including the Netherlands and Denmark, under the pressure of the growing motorization of the population. Section 4 discusses the strong civil society reaction to the "all-car" trend and government attempts to revive bicycle use in the 1970s. Section 5 explains why, during the 1980s-1990s, commercial bicycle use resumed in some countries, such as the Netherlands, Denmark and Germany, and continued to decline in others, such as France and the United Kingdom. Section 6 tries to understand why in these two countries, during the 2000s, bicycle use resumed in city centres but continued to decline in the outskirts, and underlines, among the explanatory factors, the inadequacy of the ecological argument and the relevance, on the contrary, of economic and public health arguments.

Finally, two sections emancipate themselves from the chronological narrative to open up some perspectives for the future. Drawing on the experiences of the most advanced countries, section 7 first develops some key aspects of a citywide cycling policy, such as the importance of calming the city in order to revive cycling, the necessary linkage with public transport, the crucial role of promoting cycling and winning back various publics. Section 8 then attempts a prospective exercise on the utility bicycle up to 2050: in a context of diminishing resources, the bicycle should contribute to safeguarding our mobility.

1.1. A symbol of modernity in the 19th century

The bicycle is a more complex object than it seems. This precision mechanics, which has to withstand the worst road conditions, required a wealth of ingenuity and the mobilization of the most modern techniques and materials to be developed, under no less pressure from ever more demanding users and in a social, economic and institutional context that has not always been supportive. Like any innovation, the bicycle is, in fact, a social construction and not the simple linear accumulation of technical improvements.

After having illustrated this, we will especially insist on the way the bicycle, in spite of its high cost which initially reserved it to the bourgeoisie, has gradually carved out a place of choice next to the horse, the pedestrian and then the streetcar. In three successive waves, the draisienne in 1818-1820, then the velocipede and the big bi around 1865-1880 and finally the safety bicycle from 1885 onwards, were increasingly successful, at first ephemeral and then increasingly durable and deep, as the vehicle became more practical and accessible. By its ease of use, the bicycle provides access to speed, discovery and unparalleled freedom of movement. In order to promote its development, cyclists are getting organized and are quickly demanding road improvements.

1.1.1. A concentrate of innovations

April 1815, the Tambora volcano in Indonesia erupts. Columns of ash more than 40 km high rise into the sky, reducing the sunshine all over the planet for months. 1816 is "a year without summer". Cereal and oat harvests are so poor that famine sets in. Thousands of horses had to be slaughtered and alternatives had to be found. Baron Karl Drais von Sauerbronn is a thirty-two year old inventor, full of ideas, living in Mannheim in the hard hit Rhine valley. In the nascent industrial era, when the Industrial Revolution was in full swing in Great Britain, inventors had already been looking for some time to do without the expensive and burdensome horse, or to lighten modes of transport in order to go faster. Some attempts have so far failed. Horse-drawn carriages" and other "mechanical cars", developed in Germany and France during the 18th century, are pedal cars driven by a servant, but they are not very efficient. The vélocifère and the célérifère, developed respectively in 1803 in France and in 1810 in Great Britain, are not bicycles, as so many authors claim, but light horse-drawn carriages supposed to compete with stagecoaches (Rachline, 2008).

It is in this context that Karl Drais - who had already tried around 1813 to improve a horse-free carriage - invented, at the beginning of 1817, his Laufmaschine ("running machine") allowing an individual to move quickly, seated on a seat fixed between two wheels, thanks to the alternating thrust of the feet on the ground, the mobile front wheel being steered by a tiller. On June 12, Drais covered the 14.4 km from Mannheim to the Schwetzingen post relay in just over an hour, much faster than the stagecoach. Drais's idea was truly revolutionary: "The user had not only to accept the imbalance at a standstill, but also to admit that balance would come from movement.

He therefore had to overturn a familiar logic, the one that seemed to govern all celestial bodies, according to Newton, and even the social body, according to economic theory. In other words, the amateur had to act against his intuition. He had to fight against the obvious. Slowness became the enemy of equilibrium. Stability on the ground, which was usually assured at rest, came from rapid movement.

Convinced of the importance of his discovery, Drais endeavored to patent it, not without difficulty, and then decided to market it the following year in France. The machine, renamed for the occasion vélocipède, was presented on April 7, 1818, in Paris, in the Luxembourg Gardens, in front of 3,000 people. But, too tiring, the draisienne was only a temporary success with a few dandies and other eccentrics, in France until 1820, in Germany, England and the United States a little longer.

Forty years later, in 1861, the Parisian coachbuilder Pierre Michaux and his son Ernest salvaged a boat brought in for repair. They had the idea of adding pedals on the front wheel axle to move forward without putting their feet on the ground, balanced on two wheels. This innovation aroused great interest and in 1865, with the financial support of the Olivier brothers, they created a company manufacturing “michaudines”. By 1867, thanks in particular to the Paris Universal Exhibition, which attracted 10 million people, the success of the velocipede was assured. Soon after, it will be more simply called véloce, then finally vélo.

However, this first bike remains rudimentary: its iron-ringed wooden wheels are very uncomfortable, the pedals fixed directly on the front wheel allow only a weak development, the machine remains heavy, the brakes and lighting are not very efficient... Many innovations are necessary to make this machine more practical. In an intense emulation, where the ingenuity of the inventors seeks to meet the requirements of users as well as to attract new customers, they will gradually emerge in about twenty years, with hundreds of patents filed. As demand grew, production became more industrialized: it was necessary to succeed in mass production, and then precisely adjust the 1,500 parts of a bicycle.

All these efforts began in France and continued in Germany during the 1860s, but were interrupted by the War of 1870. The United Kingdom then took over and the cycle industry was concentrated in Coventry, which already had a great deal of know-how in the manufacture of sewing machines, the other consumer durable good of the time. France and Germany returned to the race in the 1880s. The French bicycle industry was developing at that time, especially in Saint-Étienne, where skills in the manufacture of hunting weapons were already being brought together, in particular with the Manufacture française d'armes et cycles, alias Manufrance as of 1911, and its urban bicycle model, the hirondelle, which had become mythical.

1.1.2. A mechanical horse?

Domesticated since prehistoric times, the horse has gradually spread as a prestigious mode of individual travel, symbol of nobility, freedom and superiority. It reached its peak in the 19th century. Its maintenance, however, requires a stable, fodder, straw and constant care by competent personnel, which only the aristocracy and the upper middle class can afford. The horse-drawn carriages and then the first horse-drawn streetcars democratized its use a little, but racing or traveling remained expensive. Horses can achieve a few speed peaks, but they tire quickly: in fact, they are hardly faster than pedestrians. And above all, in urban areas, it causes strong nuisances: omnipresent droppings and dirt (even if manure can be valorised), nauseating odours, recurring accidents, noise of the hammering of hooves, congestion and traffic jams.

The main innovations that have led to the modern bicycle

1817: In Germany, Baron Drais realizes that a balance on two wheels is possible. His invention is called "velocipede" or "draisienne" in France.
1861: Pierre Michaux fixes pedals on the front wheel of a draisienne.
1866: Pierre Lallement improves the velocipede and creates the "bicycle" that he seeks to market in the United States.
1869: Clément Ader adds solid rubber tires on the wheels.
1870: James Starley makes wheels with tensioned steel spokes, much lighter. Tubular frames also contribute to lighten the structure.
1871: Thanks to an enlarged front wheel, the "big bi" increases the distance travelled with each pedal stroke, but it proves to be dangerous.
1880: The Englishman Henri Lawson makes a chain transmission that results in the first "bicycle", a small bicycle that is safer than the big bi.
1884: John K. Starley (nephew of James) develops the safety bicycle, or "safety bike," in Coventry, with similarly sized wheels, under the name Rover.
1888: Scotsman John Boyd Dunlop invents the tube tire, which greatly improves ride comfort.
1890: The "diamond" frame, with a triangular structure, is much more rigid.
1891: Édouard and André Michelin make the tire easily removable.
1895: Jean Loubeyre invents the principle of the derailleur.
1897: The German Ernst Sachs develops a hub with a freewheel that prevents the cyclist from pedaling when slowing down or downhill.
1902: The Englishmen Henry Sturmey and James Archer propose a hub gear shift system that is easier to maintain...
We can consider that, as early as 1891, the modern bicycle was born.

The appearance of this "mechanical horse" that is the velocipede gives rise to the formidable hope of getting rid of all these constraints. It is always to the horse that it is, indeed, compared. The English call the draisienne hobby horse (from the name of a toy for children). The Germans colloquially call the bicycle Drahtesel (wire donkey). And many people call it literally "iron horse". The bicycle has a saddle and not a seat. Even schools for learning to ride a velocipede are called merry-go-rounds.

From the very beginning, Karl Drais proves that his Laufmaschine is faster than the horse and the demonstration will not cease to be redone as the technique evolves. All the first races - such as Bordeaux-Paris and Paris-Brest-Paris in 1891 - are commented in this way. Thus, in Central Europe, a bicycle race was organized between Vienna and Berlin in 1893, on the same course as a horse race that had taken place two years earlier. As a result, the cyclists went 2.3 times faster than the riders: 31 hours instead of 72 to cover the 582.5 km, or an average of 19 km/h as opposed to 8 km/h. Moreover, in the week following the 1891 race, thirty exhausted horses were shot down, whereas in 1893 all the cyclists were doing well (Giffard, 1899).

Another argument, always put forward, is the much lower cost of the bicycle, its docility and availability. Pierre Giffard noted in 1899, "With it, there is no need for oats, hay, straw, or stables, nor for this terrible brotherhood of grooms and seed merchants that the most debonair of horsemen always suspects that they get along like thieves at a fair to extract as much money as possible from their purse. With her, one is no longer afraid of tiring his mount. She is always ready" (Dodge et al., 1996). "From the outset, the draisienne proves to be four times cheaper than a horse. (Guillerme, 1996) From then on, the inventors tried, with varying degrees of success, to replace all the horse's uses with the bicycle: walking, running, utility travel, the doctor's and country priest's rounds, transporting people, courier services, circus acts and even cavalry regiments.

Last but not least, the bicycle causes almost no nuisance. In a city like Paris, where in 1902 there were still 110,000 horses (Mom, 2009), their gradual disappearance is a pleasing prospect in the hygienic environment of the time. But it was above all the automobile that precipitated the decline of the horse, not without creating other forms of pollution (Gaboriau, 1991).

1.1.3. Sport or tourism, speed or discovery

From 1870, the bicycle became the symbol of progress and modernity. It allowed everyone to go freely from door to door, freeing them from their condition as pedestrians or riders, without the time constraints and hazards of the railroad and without the care of the horse. Its still very high price reserves it, in fact, to the bourgeoisie which uses it mainly for its leisure activities: sport and tourism. We hope that man and machine will become a couple with a fabulous destiny, says Philippe Gaboriau. With the hope of being together "masters of the world". Science and sport associated in the same adventure (Laget, 1990). "The bicycle becomes a means of social distinction.

In France and Germany, "veloce" means above all speed. Races multiplied until the first Tour de France in 1903, which consecrated, in this country, the bicycle as a mode of transport that was both fast and capable of covering the whole country (Bertho Lavenir, 2011). In 1881, the Union vélocipédique de France (UVF) was created to bring together the many clubs existing all over the country. But its main task was to organize races. In 1890, cyclists who preferred to travel decided to launch the Touring club de France (TCF), based on the English model of the Bicycle Touring Club founded in 1878 and which became the Cyclists' Touring Club in 1883 (to take account of tricycles). The aim of the TCF is to spread the culture of cycling and to facilitate bicycle travel (Ebert, 2004). It was a very quick success.

In the Netherlands, the discovery bike is immediately popular. Faced with a Germany unified by Bismarck since 1870, then with Pangermanism, the worried Dutch sought to promote their nation and found in the bicycle both a means of discovering the country accessible to all and a return to the values of the Golden Age, when the United Provinces dominated the economic, cultural and artistic world in the 17th century : strength, balance, self-control, freedom and independence. Cycling is equated with skating, an ancestral practice in this country. The Dutch General Association of Cyclists (ANWB), founded in 1883, is in the hands of progressive liberals and prefers to promote bicycle tourism rather than bicycle racing.

But, as Catherine Bertho Lavenir points out, "perhaps the homeland and the bicycle are most strongly linked in Italy. The first cycling excursions were, in this country that is still so little united, so little modern, so unsure of its destiny, of demonstrative and patriotic value. Ingegnere and commendatore of the industrial North engage on two wheels in tight groups on the roads that go from Milan to Rome and from Turin to Florence. We enter the flag cities at the head and the excursion ends with a banquet where toasts to the new Italy are offered. To discover new landscapes is to celebrate the love of one's native land".

1.1.4. A fun and liberating activity

On September 27, 1894, the mayor of Le Vésinet, Charles Drevet, signed a municipal by-law: “Article 10: it is expressly forbidden for cyclists to fight for speed on public roads and to form groups that may hinder traffic. They are also prohibited from practicing skill on busy roads by making curves or making unnecessary changes in direction that could impede traffic or inconvenience pedestrians.” (Dodge et al., 1996) This is just one of the many decrees issued in cities around the world to address the extraordinary popularity of bicycling.

As soon as it appeared, the bicycle became a game of skill very popular with adults, which it still is today for children. Achieving a dynamic balance on two wheels at all times, playing with obstacles, always keeps a magical and fascinating side: cyclists may only be grown-up children... Throughout the 19th century, acrobats explored the limits of the exercise, with breath-taking acts performed in circuses, fairs or on the street.

More prosaically, for all those condemned to walk because they don't own a horse or because they don't have adapted public transportation - the vast majority - bicycles suddenly make it possible to go three to four times further than on foot for the same energy expended, i.e. to access a territory ten to fifteen times larger. This is a prodigious gain that will help transform social relations, especially between the sexes. Until now, women were largely confined to the private sphere, away from activities such as education, work or politics, and their movements on foot were limited by heavy clothing: hats, corset, petticoats and heavy skirts revealing only the face. The bicycle suddenly allowed them to accelerate their emancipation by revolutionizing the dress code and increasing their mobility tenfold.

In order to pedal at ease, women demanded the abandonment of the corset, a freer hairstyle, more comfortable shoes and the wearing of pants, which at the time was a strictly masculine prerogative. After innumerable adventures, they obtain to be able to carry in particular skirts-breeches (or "breeches of zouave"), compromise between the skirt and the pants. A whole female cycling fashion is then constituted, which will be diffused then with other activities. The bicycle is also the occasion for the women to leave their isolation, to widen their geographical and social horizons. Some of them take the courage to ride alone in the street, but not without being subjected to a few quibbles (Thompson, 2000) Clais points out in her “Portrait of Women Cyclists”: Conservative and puritanical circles tried hard to keep women away from the machine that symbolizes strength and virility (Clais, 1998), trying to prevent what they very seriously called “masturbationary drifts” and perversions of a new kind (Carse, 1994).

Despite this, women's cycling is making progress. In 1895, for example, one-third of the 60,000 members of the British Cyclists' Touring Club were women (Gifford, 1992). In the New York World of February 2, 1896, women's rights lawyer Susan B. Anthony, states: “The bicycle has done more for the emancipation of women than anything else in the world. I rejoice every time I see a woman on a bicycle. It gives her a sense of freedom and empowerment” (Guillerme et al., 1998).

1.1.5. First bicycle facilities

The bicycle being faster than the horse, the streetcar and the very first automobiles, it was banned in France on pedestrian areas by a regulation of 1896: its natural place, it is believed, is on the roadway. Despite the origin of its name, the velocipede is logically considered a vehicle. As long as the speeds practiced by other vehicles remain modest, cyclists live with them without difficulty and do not need special spaces.

They are, however, very sensitive to poor coatings. The first velocipedes have only iron-ringed wheels, then rubber tires. The English nicknamed them boneshakers (literally, bone shakers). The invention of the tire by Dunlop, later perfected by Michelin, considerably improved comfort, but cyclists were still confronted with “appalling cobblestones [...] each of which was a small torture block” (Reverdy, 1986) and “degraded tarmac "because paved roads, alone, are always bad, while paved roads are generally very passable, except when they are repaired”. They find themselves forced to drive on sidewalks - when they exist - not without causing conflicts with pedestrians.

As a result, as elsewhere in Europe, TCF officials are calling for smooth-surfaced treads at the edge of the main radial a or, better still, “bicycle sidewalks”, a type of cycle path at an intermediate level between the roadway and the sidewalk, as many of them still exist in Denmark today. It even helps to subsidize them. In Paris, the first bicycle sidewalk was laid out very early on, on the Avenue de la Grande Armée, where many bicycle stores are concentrated because of its proximity to the Bois de Boulogne, with its asphalt back alleys and the Chalet du Cycle, which is very popular with the bourgeoisie.

Demands intensified after the introduction in 1893 of a ten-franc tax “on velocipedes and other similar devices” which at that time could be considered luxury goods. Despite the gradual democratization of the bicycle, this tax was only abolished in 1958 and was never used directly for bicycle facilities. Three other countries also taxed cyclists: Belgium progressively from 1893, Italy in 1898 and the Netherlands in 1899.

At the beginning, the first facilities are everywhere intended for leisure cycling. They are used to leave the cities in a comfortable way to discover the countryside. As early as 1897, the TCF lists the "velocipedic routes" and hills on regularly updated maps. (Lamming, 2003) The 1899 map of the Paris area distinguishes, for example, between “impassable paved roads”, “paved roads with practicable verges” and “recommended national or departmental roads”. The main thoroughfares are therefore not very passable, but developments are already being carried out in the middle-class suburbs of the west.

1.1.6. Cycling and public transportation

At the end of the 19th century and until the 1920s, streetcar networks were in full swing everywhere. They irrigated all cities and their suburbs. They were modernized and gradually became electric starting in 1890 (Flonneau, 2012). The tracks integrated into the roadways represented a danger for cyclists whose bicycle wheels got stuck in the groove of the rails.

In the city centre, the streetcar is not a serious competitor for the bicycle. Cyclists travel much faster and from door to door. However, in the suburbs and beyond, the streetcar is faster and less tiring. It competes directly with bicycles, limiting their growth. The particular density of the streetcar networks in Wallonia would explain why, at that time, cycling was less developed in that region than in Flanders or the Netherlands (Orselli, 2011).

The bicycle is rapidly becoming similar in cost to the streetcar. “In 1894, the magazine Le Cycle compared the bicycle to the cost of public transportation in Paris, which it estimated at 45 cents a day, or 135 francs a year. It gave the following figures: 400 francs [for a] very good work bicycle with pneumatic rubbers. ...] But every cyclist knows that whoever is not demanding, and especially who does not aim for elegance, can easily obtain a very satisfactory 'working' machine at 250 or 300 francs, so that, from the second year of use, the instrument is paid for nineteenth century, bicycles began to compete with public transport: "The decline is reflected in the revenue from omnibuses and [horse-drawn carriages.” (Aronson, 1951)

Like light rail and commuter rail, bicycles promote urban sprawl. Some residents are taking advantage of these new transportation facilities to live further from their place of work, benefiting from cheaper or larger housing. In large cities, it becomes a natural complement to commuter trains, allowing people to live a little further away from train stations, near which property prices are soaring. In rural areas poorly served by rail, it is the only effective alternative and is developing rapidly, although it depends on people's standard of living.

1.1.7. Rapid growth

With lower prices and improved performance and comfort, the bicycle is beginning to spread throughout society, becoming commonplace and gradually becoming a means of transportation. As early as 1895, a few cyclists were already leaving the factory filmed by the Lumière brothers. In France, thanks to the tax on velocipedes, the bicycle fleet was fairly well known until the Second World War: in twenty years, it grew steadily to reach 3.5 million vehicles in 1914. In the United States, the country was experiencing a real bicycle boom, especially in Boston and all along the northeast coast. As early as 1900, the fleet reached 10 million bicycles for 76 million people. 37 But this craze would soon fall back to the automobile.

In addition, almost all current bicycles can be equipped with electric pedal assistance. Only three factors slowed down the development of cycling in its early days: the learning curve, the condition of the roads and the purchasing power of households. In France, Germany and Great Britain, the wealthiest candidates take a few “balance lessons” in “study rides” or quiet lanes before getting into traffic. (Mom, 2004) It's not easy for adults to get on their bikes. The pavement is then a sensitive issue. In France, it often consists of large, disjointed, rounded or broken, very uncomfortable cobblestones, whereas in the Netherlands, it is mostly made of gravel or bricks that are much more pleasant for cyclists, even though they all require much more rolling tarmac. Finally, cycling is gaining ground in the richest countries, cities and neighbourhoods, where households can afford to buy at least one bicycle. The wealth of innovations in the nineteenth century is at the root of all bicycles today. Figure 1.1.1 attempts to provide an overview.

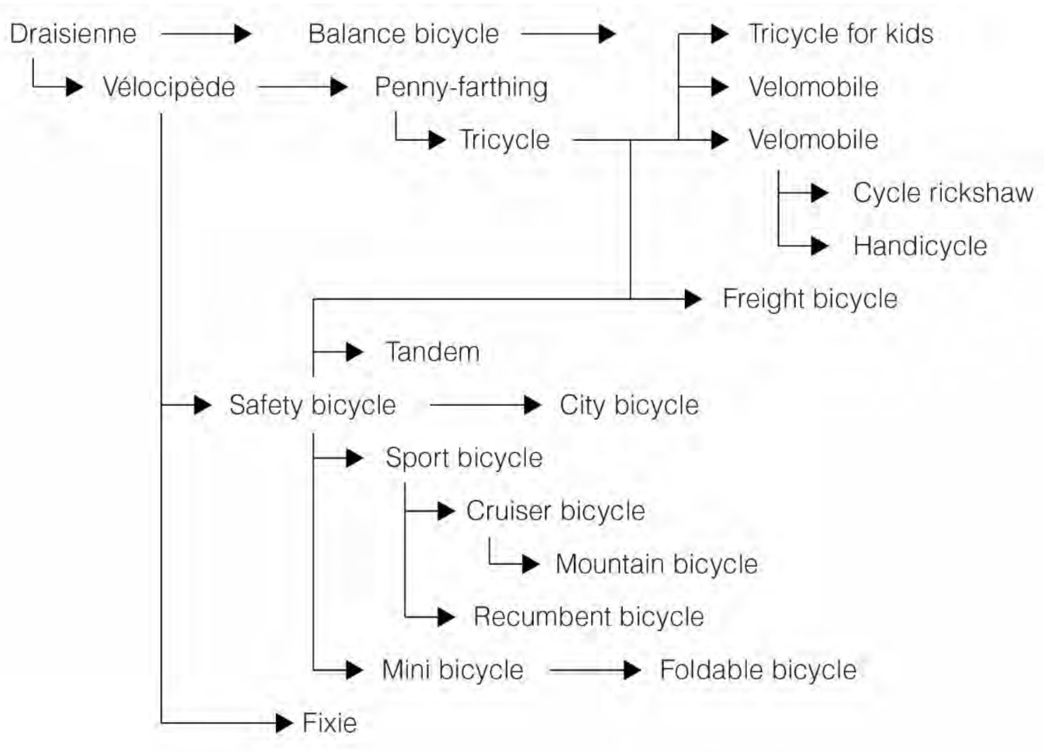


Figure 1.1.1. Origin and diversity current bicycles main types

Source: Created by the author

1.2. The massive diffusion of the bicycle in the first half of the 20th century

In the first half of the 20th century, bicycle use spread to all strata of society and almost everywhere in Europe. All but the poorest families acquired at least one bicycle, which was used to go to work, to visit, to transport children or to run errands. But the car is already beginning to take off, quickly threatening the streetcar and then cyclists, because it imposes its power and requires road adaptations that are unfavourable to other modes.

On the eve of the Second World War, the French car fleet was still modest: 2.4 million vehicles, including utility vehicles, for 9 million bicycles. A significant gap that can be found everywhere in Europe. The numerical importance of cyclists still puts them in a favourable balance of power in most neighbourhoods. Not for much longer.

1.2.1. Cycling for all

From the 1890s onwards, cycle production became a mass industry. With longer production runs, manufacturing was streamlined and prices fell continuously. At the same time, wages are no longer just subsistence wages and are finally rising. In France, for example, for a professional worker, the price of a bicycle measured in working hours is divided by ten in forty years, between 1891-1895 and 1930-1935. From then on, bicycles became accessible to the greatest number of people and spread to the working classes. Workers, employees and peasants went to work en masse by bicycle. Traffic jams of cyclists formed at the entrance and exit times of factories and offices.

Dr. James Ruffier, a daily cyclist and avid hiker, says, "Crossing the Bezons Bridge at 7 a.m. on a weekday morning, [taking me] away from Paris, I could barely keep up with the stream of cyclists who came to meet me on their way to the capital or its immediate suburbs. All these people were on their way to work. Thousands of workers went to the factories; employees went to their offices and stores; young girls, women, typists and saleswomen, pedalled to their daily work. And the funny thing, at least for me, was that this crowd of cyclists was blocking all other traffic. The few cars made their way through with difficulty, and, modest in the face of the strength of the numbers, honked their horns only in discreet little bursts. The streetcar itself, loaded with proletarians, only slid in slow motion and by slight jumps on its odious rails. ...] At the same time, throughout the suburbs, the same spectacle could be contemplated. Billancourt, Boulogne, Puteaux, Saint-Denis, Pantin, Vincennes and Malakoff are crossed, morning and evening, by four or five hundred thousand bicycles. Same thing in the big provincial cities. In Le Creusot, Saint-Etienne, Saint-Nazaire, in all the industrial cities, perhaps a third of the workers go to work by bicycle. In the same way, many peasants go to their fields by bicycle. ...] The worker has found in the bicycle the most convenient and economical means of transport to and from the place of his work (Callens, 1996).

Cars, which only the rich can afford, dominate the arteries of the bourgeois districts of the capitals, such as Paris, London or Berlin. But everywhere else, they are blocked by hundreds of cyclists who impose their slow speed and overtake them at their first stop at a crossroads. By forcing motorists to slow down and be careful of their presence, cyclists played a powerful role in moderating road accidents at that time (Gaboriau, 1991).

What, however, is the actual level of this practice in cities in different European countries? Unfortunately, there are no precise data on modal split, but we do know the level of bicycle ownership in some countries. However, it is very likely that at that time, most of the bicycles owned are actually used and, in most cases, for daily journeys. According to these statistics, it is confirmed that, in the inter-war period, cycling was highly developed almost everywhere. Unsurprisingly, the Netherlands (with 308 bicycles per 1,000 inhabitants) led the way, followed by Sweden (256), Denmark (211) and Belgium (196), and further afield, Germany (172), France (167) and England (141). Since these three countries are hillier than the first, the differences are finally quite small. In other words, before the war, the French used bicycles as much as the Germans (four times less today) and almost as much as the Danes or the Belgians. As for Italy, its low ownership rate (75) is mainly explained by its relative poverty. And the United States (14) has already switched to cars.

1.2.2. An egalitarian mode of movement

During the 1930s, the bicycle became the symbol of individual mobility, free and accessible to all, which easily escapes all control. It was first and foremost a general-purpose vehicle available in a wide variety of equipment: utility bike, tricycle, touring bike, tandem, carrier bike, scooter, trailer, etc. It was used for daily or leisure trips of considerable scope, making it easier for people to exchange information, take care of household supplies, transport children, make deliveries, and go on vacation.... "The bicycle, recalls Philippe Gaboriau, becomes the first useful means of locomotion, which moves away from the factory, brings the urban employee and worker closer to the countryside, the peasant and the rural worker closer to the city" (Paquot, 2009). The bicycle is the first useful means of locomotion, which moves away from the factory, brings the urban employee and worker closer to the countryside, the peasant and the rural worker closer to the city. It is also an inexpensive tool, both to purchase and to use, which requires only the muscular energy of its user and which is simple enough to be repaired by itself most often.

We buy it with our first salaries and we pamper it so that it lasts a long time. Finally, it is a tool for self-affirmation and socialization, allowing one to test one's strength and sense of balance, to reach autonomy for adolescents, to emancipate oneself for women, to multiply encounters, to find and keep a job... For a worker, if it is stolen, it is a catastrophe (see The Bicycle Thief, by Vittorio De Sica, 1948) (Giffard, 2000).

The vast majority of these new cyclists are obviously former pedestrians. This is regrettable, since the pedestrian is the foundation of urbanity and social life. But, from this point of view, the cyclist is only a pedestrian-cyclist - literally a cyclist with a bicycle -, non-motorized, who moves without causing any nuisance, at moderate speed and using little space. From this point of view, the bicycle is an eminently urban mode that adapts well to the city and respects others, causing few accidents. All these characteristics and others (see box opposite) make cycling a mode of travel that promotes more egalitarian relations and a democratic society.

In the inter-war period, however, the bicycle became an exclusively "popular" good, as the bourgeoisie gradually switched to the automobile. Nevertheless, one country stands out in this respect: the Netherlands. Very early on, the royal family found in this mode of transportation the means to show itself, by using it, as being "close to the people" and it has maintained this image ever since. Like a good part of the aristocracy of the time, Queen Wilhelmine became infatuated with the bicycle as a teenager (she was born in 1880 and reigned from 1898 to 1848). Her daughter Juliana, at the time of her marriage in 1936, made a bicycle tour with her husband in The Hague after the ceremony (she reigned from 1948 to 1980). We even speak then of "monarchy by bicycle". (Stoffers, 2012). Her daughter Béatrix did not hesitate either to ride a bicycle (she reigned from 1980 to 2013). This display contributes to giving the bicycle a "civilized and respectable" image in line with "the trend towards egalitarianism in Dutch politics and society Batavus, the name of the tribe that would be at the origin of the Dutch nation (Aronson, 1951).

1.2.3. The rise of the automobile

From the beginning of the 20th century, the automobile brilliantly took over as a symbol of progress, freedom and modernity, thanks to performances that quickly became much superior to those of the bicycle, with greatly increased travel distances, much less effort to be made and incomparable comfort. All these qualities immediately conquer the elite, who consequently demand a road network and services to match.

It must be said that the bicycle has perfectly prepared the ground for him in all areas, in Europe and even more so in the United States (Yonnet, 1984). First of all, it has given everyone a taste for new mobility and autonomy based on an individual mode of travel that is much less restrictive than the horse, the streetcar or the railroad. It then required the development of a bicycle and accessory manufacturing industry and a distribution and repair network now ready to move into the emerging automobile market. This is the case, for example, of Peugeot in France, originally a manufacturer of bicycles, tricycles and quadricycles, Rover in Great Britain and Opel in Germany. In addition, powerful cycling associations - including the TCF - have already improved road maps and signage, revitalized the hotel and restaurant industry, and called for better road surfaces. Finally, a very dynamic press is ready to get excited about the automobile.

This mechanism is an essentially Franco-German invention. After the British stalemate of the steam automobile, it was in fact French and German engineers who, after much trial and error, succeeded in developing a four-stroke petrol-powered internal combustion engine, thanks to the efforts of Karl Benz, in 1886, in Mannheim, in the very city where the draisienne had been invented seventy years earlier. The 1890s saw the appearance of the first car manufacturers (Panhard and Levassor, Peugeot, Berliet, Renault, Benz, Daimler...). The first car show opens in 1902, in Paris. In 1903, France alone produced half of the 62,000 cars manufactured in the world. France is indeed the main cradle of the automobile.

Other large countries (by population) are gradually developing their own car industry: Germany, the United States, the United Kingdom, Italy, Spain, Japan... But no small country manages to create a strong and sustainable car industry: Belgium makes a few cars before the war thanks to the Dasse company and the Fabrique Nationale de Herstal, Austria produces Fiat cars under licence until 1976, with the Steyr-Puch company, and the Netherlands builds Daf from 1958 to 1976. Denmark, Norway and Switzerland have no automobile production. The only exception is Sweden, which has two major manufacturers with Volvo (from the 1930s) and Saab (from the 1950s). As a result, these small countries will experience a slightly later motorization, with the exception of Sweden, which had an earlier motorization. These differences will be crucial when the authorities seek to revive bicycle use in the 1970s.

Whereas in the United States, from 1913 onwards, the rustic Ford T, originally intended for the rural world, was mass-produced at low cost through the use of line production, in Europe, until the Second World War, the car was still considered a luxury good reserved for the rich, but which already exerted a great fascination on the whole of society (Pinon, 2002). The first mass production projects for small models emerged at the end of the 1930s (Beetle, 2CV, 4CV, Fiat 500) and were interrupted by the war.

1.2.4. The first efforts to adapt the city to the automobile

With the advent of horse-drawn and then automobile transport, which is very space-consuming, congestion is increasing everywhere in large cities. It is urgent to make room for this traffic. Public pressure is very strong. Newspapers are full of recriminations from users who complain about traffic jams. Some titles are waging virulent campaigns in favour of the automobile. Many solutions were tried out as early as the 19th century and especially in the inter-war period. The largest cities were of course going to play a pioneering role, which was not without consequences for cyclists.

The breakthroughs - which aimed to create new streets by not hesitating to destroy buildings - really began in Paris at the beginning of the 19th century, with the exception of the rue Royale created in 1775 (Darin, 1988). They accelerated under the Restoration and especially during the Second Empire, when the city acquired the legal and financial instruments necessary to carry out expropriations and works. Haussmann's breakthroughs were certainly intended to facilitate the circulation of carriages, but also to eradicate unhealthy housing, build quality buildings and improve underground networks (water, sewers, etc.), in short to revitalize the centre. These works are highly admired for their audacity and many other French and European cities are now imitating the capital (Barles et al., 2008). The breakthroughs initially made it easier for cyclists to get around. However, as they soon become increasingly dense and fast-moving traffic, they become dangerous arteries: cyclists are forced to take refuge in the adjacent lanes.

The creation of major metro networks in the major capitals - London in 1863, Paris in 1900, Berlin in 1902, Madrid in 1919, etc. - certainly improves public transportation, but the goal is also to eliminate surface omnibuses and streetcars to free up the space needed for growing traffic. About as fast, safer and more comfortable, the metro is a direct competitor to the bicycle.

The first experiments with one-way parallel arteries were carried out in the 1920s in Paris with the group formed by the rue de la Chaussée d'Antin and the rue de Mogador, followed progressively by a few other streets (Héran, 2009). These one-way streets speed up and intensify traffic, complicate and lengthen cyclists' journeys and ultimately threaten their safety (Dreifuss, 1995).

Following the American experiments of the 1910s, the first traffic light appeared in Paris in 1923, at the crossroads between boulevards Sébastopol and Saint-Denis, then gradually in other major European cities. Green waves - i.e. crossroads with synchronized traffic lights designed to facilitate traffic flow - were created from the 1930s onwards. Adapted to the speed of cars, they forced cyclists, on the other hand, who were travelling more slowly, to make frequent stops requiring painful restarts that were costly in terms of muscle energy.

The first grade-separated crossroads, also invented in the United States, also appeared in Europe, first in Paris, apparently in the 1930s, on the Boulevards des Maréchaux. Tunnels were such a danger for cyclists that they were soon banned.

In France, on-street parking was originally strictly forbidden. However, under pressure from motorists who leave their vehicles on the street for convenience or because they cannot afford to buy a garage, it is gradually being implicitly tolerated (Piednoir, 2008). The law of May 30, 1851 on the traffic police and the decree of August 19, 1852 initially prohibited "the unnecessary parking of any harnessed car on the public highway. Article 11 of the decree of December 31, 1922, instituting the highway code, further recalls the prohibition on "leaving a vehicle parked unnecessarily on the public highway. However, in 1928, this article 11 was amended and the expression "without necessity" was replaced by "without legitimate reason". Comparison with other countries remains to be made, but it is likely that the developments are similar. In any case, cyclists suffer in many ways. Parked vehicles gradually invade space - the sides of roads and lanes, central and lateral medians, squares and other vacant spaces - making non-motorized users less visible. A certain tolerance is developing that encourages illegal parking, especially on bicycle facilities, degrading their surfaces and causing inconvenience and traffic jams. The search for on-street space, parking and parking manoeuvres, and the unintentional opening of doors are also sources of increased danger for cyclists.

The high energy efficiency of the bicycle

Various studies begun at the end of the 19th century have made it possible to understand the energy expenditure of cyclists, which can be measured in joules (J) (Tucker, 1975). It is thus known that a cyclist weighing 70kg + 15kg for his bicycle travelling at a speed of 20km/h on a flat pavement with the correct surface and in the absence of wind expends an energy of about 16J/m. Since speed depends heavily on air resistance, wind is a much more formidable obstacle than rain. On flat ground, the cyclist spends about 3.5 times less energy than the pedestrian per kilometre travelled, at least when there are no stops. He can therefore cover an area about 12 times larger. For a cyclist traveling at 20 km/h, a restart after a stop represents an extension of the route by about 80m. We deduce that if there is a traffic light every 400m (a common situation in large French cities) forcing the cyclist to stop every other time, i.e. every 800m, these stops due to traffic lights are equivalent to a 10% increase in distance. In Paris, where intersections with traffic lights are located on average every 150 m, this is at least 20%. It is easier to understand why cyclists so often consider stops and red lights to be a "give way". In order to move their mass vertically, a cyclist with his or her bicycle expends about 50 times more energy than is required to move their mass horizontally. The effect of gravity related to the slope is very penalizing for the cyclist. In practice, thanks to the derailleur, he can climb a 5% slope without difficulty, but at the expense of speed. Rising one meter is therefore for him a detour of about 50m. But, unlike the pedestrian, thanks to the invention of the wheel, the freewheel and the tarmac, the cyclist can use his gravitational potential energy on descents and cover large distances without any effort other than the possible pressure of his hands on the brakes. In a well-documented article comparing the energy efficiency of animals and modes of transportation in moving their own weight, American biologist Vance A. Tucker demonstrates that the cyclist is the most efficient of all, ahead of, for example, the salmon, airplane or ice skater.

1.2.5. The disappearance of the streetcar

The question of the fate of the streetcar, a priori irrelevant, is in fact central. The disappearance of streetcars leaves the field open to cars and cyclists are directly threatened. However, the fortunes of the streetcar have been very different from one European country to another.

In France, all networks are dismantled in about 60 years. In 1906, in Paris, the Compagnie Générale des Omnibus (CGO) introduced the first buses to replace the last horse-drawn streetcars. As early as 1921, the Seine prefecture planned to eliminate certain lines in the narrow streets of the central districts to facilitate car travel and deliveries. From 1925 to 1937, in just twelve years, the entire Parisian network was dismantled and the suburban network was finally dismantled in 1938 (with the exception of Versailles) (Emangard, 2012). In the provinces, the complete closure of the networks began with that of La Rochelle in 1931 and was completed with the major provincial networks between 1950 and 1964. Only three lines survived: in Marseille, Saint-Étienne and on the Grand Boulevard linking Lille to Roubaix and Tourcoing. In the United Kingdom, the disappearance of streetcars was just as rapid and massive. In Germany, on the other hand, the major cities are reducing the extension of their lines, but most of them are keeping most of their network (Larroque, 1989). How can these differences be explained? The tidal wave of the "all-car", of course, is the main component of the process leading to the decline of the streetcar," explains Dominique Larroque. Nevertheless, all Western countries are faced with the new technological situation, but none of them has reacted with the same intensity as the French example. The explanation is therefore not sufficient" (Offner, 1988).

In France and the United Kingdom, both cities and the state have a very liberal approach to urban transportation. Public transportation companies are required to be managed at the concessionaire's risk. There is no question of subsidizing them or helping them in the event of cyclical difficulties, as was the case during the economic crisis of the 1930s. Cities have no means of intervening in their activities and are incapable of demanding quality of service. They can only encourage competition from other companies, trolley buses and buses. In Germany, on the other hand, transport operators are backed by highly profitable power companies that originally expanded their operations to include public transport to increase their market opportunities (Cherki et al., 1979).

Similarly, both the French and British authorities consider, from the outset, that the user must pay for the transport service in such a way as to cover operating costs, according to a principle of "true price". There is no question of the taxpayer making up the operating deficit of the carriers. This doctrine led the French government, for example, to raise the price of metro tickets in Paris in the late 1960s, to the point of provoking fierce protests from users (Le Breton, 2002).

As a result, French public transportation companies are also adopting a very Malthusian approach to their business. The aim is to preserve profits in the short term by reducing investments to a minimum and limiting network modernization to what is strictly necessary. Each line must be profitable: there is no question of equalization between lines. Nor is there any question of mutual aid between companies, each defending its monopoly on its own territory (Emanuel, 2010).

As a result, French companies have not been able to modernize their networks. Competing with cars and buses, they are first of all structurally loss-making. Then, when heavy investments are required, the bus solution is always more attractive in the short term, less disruptive to traffic and much less expensive, since buses do not pay for the roadway, unlike streetcars, which pay for their rails. Finally, private transport companies are developing competing and very attractive bus services on the most profitable streetcar and rail lines.

However, one explanatory factor is missing from all these considerations: the competition of the bicycle itself. By the end of the 19th century, it was cheaper and much faster to travel by bicycle than by streetcar, as noted in the previous section. In Stockholm, for example, the overpriced, often crowded and infrequent light rail system was abandoned by the working classes, who preferred the bicycle by far (Guillerme et al., 1998).

1.2.6. The automotive lobby in action

The automobile has a defect: because of its mass and speed, it can become very dangerous. With the growth of ever faster traffic and the transformation of streets into real roads, accidents are rapidly multiplying: "50,000 in Paris in 1919, of which 34,000 were caused by cars, 60,000 in 1920, 80,000 in 1926 (Guillerme et al., 1998). “But it is not speed that is being blamed - there is no question of curbing this symbol of modernity - it is the other users who are bothering motorists. When he is involved, the [presumed] person responsible is always the careless, reckless, foolhardy pedestrian” (Lannoy, 1999).

However, as long as the automobile remains considered a luxury good reserved for the richest, and this was the case in Europe until the Second World War, its promoters are obliged to exert pressure on the authorities and public opinion to impose their views. As early as 1895, they organized themselves and created the Automobile Club de France (ACF), a prestigious private club, soon to be located at the Hotel Plessis-Bellière, Place de la Concorde. The German equivalent was founded in 1903 and became ADAC (Allgemeiner Deutscher Automobil-Club e.V.) in 1911. The aim of these clubs was to promote motoring: to foster the automobile industry, encourage road construction and fight, more prosaically, against all obstacles to its development.

In France, the first highway code appeared in 1922. It was drawn up for motorists only. Its name is already a whole program: the street is assimilated to a road (as also assumed by the British Highway Code introduced in 1931). The code was clearly intended to discipline pedestrians, stating in section 55: "Drivers of any vehicle shall warn pedestrians of their approach. Pedestrians, having been duly warned, shall pull over to allow vehicles to pass...". Pedestrians and cyclists are seen as obstacles, impediments to traffic (implying cars), which is seen as a source of progress and wealth (Buiter et al., 2003).

In Germany, the highway code was only created in 1934 by the Nazi regime. The term that designates it, Straßenverkehrsordnung (road traffic regulations) is more neutral since there is only one word in Goethe's language to say road and street: Straße. In the Netherlands, the expression used - Reglement verkeersregels en verkeerstekens (RVV, traffic and signalling regulations) - is even more neutral, since it emphasizes the rules of behaviour when travelling, without reference to place. As can be seen, the French automobile lobby appears to be at the forefront of the battle in Europe. Genuine press campaigns effectively relay its demands.

All over Europe, the automobile is still a very small minority among street users, but it has its own volume, mass, speed and modernity, which are essential for everyone. For example, in Amsterdam, to facilitate car traffic, a green wave was created in 1930 in Leidsestraat, a 9m-long shopping street with access to the centre. Yet 33,000 pedestrians, 30,000 cyclists, 25,000 streetcar passengers and only 5,000 cars (7,000 to 8,000 people, 8% of the street's users) use the street every day. However, the speed of the green wave was gradually increased from 20 km/h to 30 km/h in 1934 and 40 km/h in 1939, penalizing the vast majority of users (Welleman, 1995). The speed of the green wave was gradually increased from 20 km/h to 30 km/h in 1934 and 40 km/h in 1939, penalizing the vast majority of users.

1.2.7. The extension of cycling facilities

We remember that at the beginning, cyclists were asking for cycling facilities to avoid bad surfaces and to have much more rolling surfaces. As soon as the automobile boom began, its promoters also demanded them, but for a completely different reason: to clear the roadway of cyclists who were obstructing it. The idea was put forward at the first International Road Congress held in Paris in 1908. In 1920, the Dutch equivalent of this congress noted that the construction of bicycle paths along major roads relieves the traffic of an extremely annoying element: the cyclist. Dr. Ruffier was even more categorical: "The bicycle paths are not established to do us a favour, but to rid motorists of our presence". Moreover, when they exist, bicycle paths become mandatory. With the progressive tarring of streets and roads, cyclists should have lost interest in the subject, but they will continue to demand bicycle facilities for a new reason: to escape the growing danger posed by the rise in motorized traffic, finding an objective ally among motorists in this demand. The rise of motorization paradoxically favours the construction of bicycle paths.

Three types of developments coexisted at that time: bicycle over widths, the right-hand lane being widened to 4m to make it easier for cars to overtake cyclists (a sort of ancestor of the bicycle lane, but without markings); “bicycle sidewalks”, actually placed at an intermediate level between the roadway and the sidewalk, which makes them very safe and leaves cyclists clearly visible to motorists; and bicycle paths themselves, clearly separated from the roadway by a curb, a median or parked cars. The first two types of facilities are mostly recommended in urban areas and the third type in the countryside, along roads or off-road.

In France, the history of cycling facilities is still largely undone. According to various testimonies, overwidths have mainly concerned entrance arteries in certain cities, such as Strasbourg, and bicycle sidewalks were more common in factory towns, such as those in the Nord-Pas de Calais mining basin. A few rare tracks were built along roads, such as the one that served the Montbéliard industrial basin between Sochaux and Audincourt. In total, according to historian André Guillerme, the line of tracks built before the Second World War was only 1,200 km long and then disappeared for the most part. This mediocre result is to be compared to the 700,000 km of road network at that time, an immense network, of great density and including a number of small quiet roads, built mainly in the 19th century and aging, unable to support the growing traffic of cars and especially trucks. The authorities have great difficulty maintaining it in good condition and consider the creation of secondary cycling facilities to be of secondary importance.

The first of the obstacles to the extension of utilitarian cycling “comes from the roads”, Dr. Ruffier estimated in 1929. The roads around Paris and most major cities are abominably paved; it couldn't be done better to make bicycle traffic impossible. Henry de La Tombelle, a figurehead in bicycle tourism, adds: "The bicycle sidewalks are the most defensible and we ask for them. But we would like these sidewalks to be specifically bicycle-friendly, instead of being sometimes non-existent or crowded with pedestrians and all kinds of filthy horrors, sometimes real blackcurrant traps, sometimes narrowed between a bulging curb and a row of children's trees or poles of all kinds. (Gardon, 2009) "The introduction of bicycle sidewalks on departmental roads in urban areas also required that the general council and the municipality agree on their respective responsibilities and funding.

In the Netherlands, two fortuitous circumstances will contribute to the development of bicycle facilities (Ebert, 2012) . As everywhere in Europe, the first bicycle facilities were built at the request of cyclists' associations to encourage tourism. However, during the First World War, the country remained neutral and found itself isolated in the middle of the warring parties, subject to the blockade of Germany by the English. Deprived of petrol, cars remained in the garage and the elite rediscovered the interest of cycling. The influential ANWB - the Dutch Cyclists' Association, still led by “upper middle-class members”, obtained the accelerated construction of tourist bicycle paths, using "the symbol of the bicycle to reaffirm the neutral, balanced and balanced Dutch identity.

In 1924, another circumstance contributed to the strengthening of cycling facilities. To make up a large public deficit and finance the road network, the bicycle tax, which had been abolished in 1919, was reintroduced at the rate of 3 guilders per bicycle (bearing in mind that a regular bicycle cost about 60 guilders). In response to protests from the ANWB, which considered that the tax was hitting the poorest people hardest, the government made some concessions and eventually agreed that new or rebuilt roads should be flanked by bicycle lanes, in the best interests of both cyclists and motorists. By 1938, the country had a total of 2,675 km of bicycle lanes, 37 percent of which are off main roads and 63 percent along main roads (the road network is 6,120 km long).

In Germany, the first achievements were halted by the First World War. After the war, several attempts to introduce a bicycle tax failed in the face of various protests. Moreover, cyclists were divided, represented by three different associations - workers, bourgeois and Christians - and had difficulty making themselves heard. Nevertheless, 2,500 km of bicycle paths were built before 1933. Their realization then accelerated with the arrival in power of the Nazis, who advocated access to motorization for all on open roads and highways that were forbidden to bicycles, and therefore flanked by bicycle paths. Some 8,500 km of bicycle paths were then added to the network, bringing it to 11,000 km in 1939 (Vinti, 2016).

1.2.8. The invention of bicycles with auxiliary motors

A final detour is required on the side of motorized two-wheelers, whose key role will be discovered in the next section. As early as the end of the 19th century, inventors have been trying to motorize bicycles. Given the weight of the first engines and the still rudimentary suspensions, the result was, at first, a heavy, fragile and dangerous vehicle. However, progress was rapid, and in the early 20th century, several manufacturers introduced motor bicycles that weighed only 25-28 kg but were still expensive. The first motor bicycles were designed for use in a variety of situations.

On September 12, 1925, to clarify the market, a French government decree introduced a new category of two-wheelers: bicycles with an auxiliary motor (BMA) with three conditions: weighing a maximum of 30 kg, not exceeding 30 km/h and capable of being operated by pedals. Despite these restrictions, the use of these new machines, considered by the legislator as simple improved bicycles, is poorly regulated: registration is not required, a driver's license is unnecessary, the engine capacity is not limited and no age limit is set. A 10-year-old can ride a BMA.

The crisis of 1929 slowed down the motorcycle boom and gave a chance to small, much cheaper motorcycles. Manufacturers of motorized two-wheelers accelerated the development of BMAs. Very quickly, their obsession was to circumvent the law in order to expand the market: To meet such draconian specifications, manufacturers presented a basic version, stripped down to the bare essentials, and then offered the customer numerous options, which transformed the original "dragonfly" into a real small motorcycle, perfectly equipped but without the weight of the various add-ons on the lead sheet. With clutch and two or three-speed gearboxes, these BMAs became real motorcycles in reduction and the 30 km/h concept was somewhat forgotten. On August 20, 1939, a decree raised the weight limit to 35 kg and set the engine capacity at 100 cm3, which somewhat reduced these overflows.

1.3. The General Collapse of Utility Bicycling in the Post-War Years

After the Second World War, all European countries without exception experienced both a rapid rise in motorized traffic and a decline in the use of utility bicycles, including the most cycling countries today such as the Netherlands and Denmark. It is therefore wrong to believe that cycling has always existed in these two countries and that it would be an eternal part of their national culture. But it did not start everywhere at the same time and did not evolve at the same pace, for many reasons that need to be understood.

Many factors other than motorization have indeed played a significant role and have contributed to differentiate situations in this practice, according to countries and cities, during the post-war growth period. Thus, the use of motorized two-wheelers, direct competitors of the bicycle, was sometimes encouraged or, on the contrary, supervised. The persistence of some populations to travel by bicycle has been ignored or respected. As for public transport, it has been more or less maintained.

The French case, which it has been more or less possible to reconstruct, will serve as a framework for this section. Some insights on other countries, unfortunately much more incomplete, will serve as a counterpoint. Indeed, there is a lack of data on this period, as the lack of interest in cycling is so general. It seems that, to date, the only in-depth work on the reasons for the decline of cycling during the Glorious Thirty Years concerns the case of Stockholm, a city marked very early on by the invasion of cars.

1.3.1. The extraordinary growth of mopeds: a French peculiarity

In the post-war years, France was the only country in Europe, along with Italy and the United Kingdom to experience considerable growth in moped travel. This astonishing phenomenon was mainly due to the ingenuity and dynamism of a few manufacturers who succeeded in imposing their views, in the face of French authorities that were indulgent, to say the least.

On June 5, 1943, in the middle of the war and probably under pressure from representatives of the profession, the Vichy regime created by decree two new categories of two-wheeled vehicles: the "bicycle with an emergency motor" with a cylinder capacity of less than 50 cc and the "moped" with a cylinder capacity of 50 to less than 125 cc. Weight and speed constraints are removed. Only the cubic capacity limits are specified. No age limit is set and the 49 cm3 two-wheelers are still considered as simple bicycles without motor.

It was not until the revision of the Highway Code in 1954 that the age limit of sixteen years for moped riders was introduced, without any permit or registration still being required (Articles 186 and 187). The emergency motor bicycle is occasionally renamed "moped" (Article 188). It was not until August 10, 1957, that a decree finally set an age limit of fourteen years for driving a moped, and moped drivers were required to have an A1 licence. The decrees of 1925 (see Section 2) and 1943 appear, with hindsight, to have been extremely permissive. They will have a significant impact on the motorized two-wheeler industry and, in turn, on cycling.

In 1940, the Solex company, the world leader in carburettors for automobiles, developed the prototype of the Vélosolex, a vehicle starting from only 38 cc. Marketed in 1946, this small moped quickly became a huge success: 25,000 units were produced in 1948, 50,000 in 1950, 100,000 in 1953, 400,000 in 1964 at the peak of production, which then steadily decreased until production was stopped in 1988. Total sales reached 8 million units. In 1949, Motobécane decided to take up the challenge and launched the AV3 Moped, with a displacement of 49 cc. It is a more powerful model than the Solex and at first hardly more expensive. In these different versions, the "Mob" will be sold a total of 14 million units until the 1990s. Finally, in 1950, Peugeot brought out the BMA 25, a bicycle with an auxiliary engine, then, in 1956, the Peugeot BB and, from 1968, the 101 to 104 series, in order to compete with the Mobylette. In Italy, the Piaggio firm invented the Vespa (the wasp) in 1946, a 98 cc scooter, which was a great success in that country during the 1950s and 1960s and a passenger success in France.

From the outset, there was a clear desire to motorize the cyclists. The very name Vélosolex bears witness to this, and its commercial slogan is explicit: "a bicycle that rides by itself". Charles Benoît, the inventor of the Moped, is not to be outdone: "a bicycle with a good little permanent tail wind". And it's logical that Peugeot - originally a bicycle manufacturer that expanded its business to include automobile construction at the end of the 19th century - should complete its range with mopeds in the hope that its customers will one day buy a car of its brand.

Success was so rapid that, as early as 1954, the French industry conquered the number one position in the world market for motorized two-wheelers and held it until the arrival of Japanese competition in the early 1960s. On the French market alone, from 1955 to 1975, the three main manufacturers sold around one million mopeds each year. In the 1970s, observers began to talk about the two-wheel phenomenon and a forecasting error concerning the unexpected decline in the use of light two-wheelers - i.e., bicycles and mopeds.
Through innovation and advertising, manufacturers have succeeded in segmenting the customer base by convincing the French that bicycles should be reserved for leisure or professional sports, and mopeds for utilitarian or leisure travel without fatigue (Averous et al., 1976). This has led to the development of bicycle tourism for country touring enthusiasts and sports bikes for Tour de France followers, on the one hand, and of mopeds, on the other hand, to escape the constraints of pedalling, growing traffic jams in urban areas and the increased distances associated with the new growth of suburban areas. The fact that, from the 1960s onwards, bicycles were no longer really considered a mode of transportation was due to the success of this marketing strategy and not to the growing success of an increasingly high-profile Tour de France.

Moped manufacturers' advertisements are particularly aimed at teenagers. They inundate the youth press, which at the time was printing millions of copies. They exalt the autonomy and escape that allow a break from daily life and the family straitjacket (Orselli, 2011).

1.3.2. The consequences of the French authorities' laxity towards motorcycles

This commercial success is also due to the low constraints on these small two-wheelers, whether it is the poorly controlled speed, the very low age limit for the driver or the mandatory wearing of a helmet, which has been postponed for a long time, as shown by some comparisons with other European countries.
We remember that in France, the speed limit for BMAs had been set in 1925 at 30 km/h, but that it was quickly exceeded by the progress of technology. The 1943 decree no longer set any speed limit. By 1960, the situation had changed considerably, as Jean Orselli points out: “As the technical progress of engines continued, almost all mopeds exceeded 50 km/h, the majority exceeded 60 km/h, and some even reached 87 km/h. And, as a result, almost all mopeds were well below the 125 cc limit and reached 120 km/h at a good speed.”

Thus, on January 1, 1964, their speed was finally limited by construction to 50 km/h, then in 1969 to 45 km/h, as a result of European harmonization, this speed being a compromise between the German and French limits of 40 and 50 km/h respectively. The engines were then routinely unbridled and sometimes inflated. Manufacturers themselves make the unbridle possible, and dealers offer and perform it as a commercial gesture! Periodically, orders and circulars try to curb this phenomenon, without much success.

In 1996, the League Against Traffic Violence still estimates that people under 50 cc's are actually driving at more than 60 km/h and some even at more than 100 km/h without proper handling and braking. As a result, their drivers are completely illegal: they are no longer really insured (the insurance company refuses to pay in case of an unbridled accident), do not respect the 60 km/h city limit, then 50 km/h from 1990, and do not have a driver's license, even though a license has been mandatory since 1958 when one rides a motorized two-wheeler at over 50 and then 45 km/h (Héran, 2017).

These criminal behaviours persist because controls are extremely rare and are still rare today. According to a recent report (Héran, 2017), there is a technical control brigade (BCT) that checks whether the two-wheelers are not unbridled and carries out noise measurements, but it is composed of only about twenty agents, whereas, according to the BCT's estimates, “more than 90% of two-wheelers are unbridled” (Pucher, 1988). The situation should finally change with the introduction of mandatory technical inspection for two-wheelers.

The obligation to wear a helmet was slowly introduced in no less than six stages, making the message unclear: first for moped drivers in 1961 outside built-up areas, then in 1973 in built-up areas, and for their passengers in 1974, then for moped drivers in 1976 outside built-up areas, then in 1979 in built-up areas, and finally for their passengers in 1984. During the 1960s and 1970s, young people as young as fourteen could ride without a helmet at speeds of over 60 km/h without moving many people. This age limit is not insignificant: fourteen is the height of adolescence, with all that this entails in terms of the desire to escape and transgression. Some already enter apprenticeship, others soon enter vocational or classical high school (schooling became compulsory until the age of sixteen in 1958). On this occasion, the teenagers demand a moped from their parents. Access to this machine becomes a kind of rite of passage to adulthood. Little by little, there is no longer any question of arriving at the learning centre or the high school on a bicycle.

In Germany, the production of motorized two-wheelers was first limited, after the war, by the Allied Council to less than 40 cc. Then, in January 1953, this ban was lifted and the moped category - called Moped - was introduced, with a cylinder capacity of less than 50 cc, a maximum weight of

33 kg and, above all, a minimum age of 16 years. Three years later, the weight limit was abolished, but a maximum speed of 40 km/h per construction was introduced. In April 1965, a new category was created, that of the Mofa - Motorfahrrad - limited to 25 km/h per construction and authorized from the age of fifteen. In the Netherlands, the age limit for all small two-wheelers was 16. In both countries, engine restrictions are much better respected and controlled. As for the wearing of helmets, it became mandatory in Germany in 1976 for Mokicks (i.e. mopeds), 1978 for Mopeds and 1984 for Mofas, without distinction between drivers and passengers, in built-up areas and outside built-up areas. With all these constraints, the moped is much less attractive to German or Dutch teenagers than to French teenagers.

The laxity of the French authorities has two major consequences: a faster decline in cycling than elsewhere and a terrible increase in motorized two-wheeler accidents. In 1978, France and Germany had the same proportion of two-wheeler users - whether motorized or not - (11%). However, while in Germany almost all two-wheelers are cyclists, in France, 55% of the riders are motorized two-wheelers - a unique case in Europe (Averous, 1977). In Germany, however, the proportion of motorized two-wheelers was almost twice as high as in France. (Carré, 1992)

The second consequence is that users of motorized two-wheelers pay a heavy price for road accidents. In 1960, their road mortality rate was even higher than that of the still few motorists (2,629 versus 2,540). At the end of the 1960s, they alone accounted for 20% of road deaths in France, 90% of which were moped riders. Of the teenagers killed at that time on the road, all modes combined, 60% were killed in moped accidents (Orselli, 2011). And, due to the lack of bodywork, motorized two-wheeler users are more frequently seriously injured and suffer more after-effects.

The authorities responded by taking a first series of measures. In January 1958, insurance became compulsory for all motorized two-wheelers and an A1 license was now required to drive a moped. These measures led to a collapse in sales of motorcycles and mopeds. But increasingly fast, often unbridled and poorly controlled mopeds are taking over. It was not until the beginning of the 1970s and the alarming increase in accidents - more than 2,500 moped riders killed per year between 1968 and 1973 (Wolf, 1992) - that other measures were taken, particularly on helmet use. In 1973, the minimum age for driving a motorcycle was raised from 16 to 18, but the limit for driving a moped remained at only 14, which is still the case today.

These measures, together with better information for families on the risk of accidents involving motorized two-wheelers, would finally cut moped sales by a factor of four between 1974 and the end of the 1980s (Gerondeau, 1979).

How can it be explained that in France, contrary to what happened in Northern Europe, manufacturers and users of motorized two-wheelers have benefited for such a long time from such great tolerance on the part of the authorities, at the cost of tens of thousands of victims, many of them teenagers? The industrial lobby first played a crucial role. Christian Gerondeau, the first interministerial delegate for road safety from 1972 to 1982, points out, for example, that the project "to make the wearing of helmets mandatory for moped riders [...] led some to ensure that this measure would put an end to the French moped industry. A national export industry, which has become the world's leading producer, is not easily brought to its knees. But other reasons certainly played a role. No doubt there was also a certain fatalism typical of that era before road insecurity finally became a national cause in 1973, when more than 17,000 French people died on the road.

In any case, the very rapid growth of motorized two-wheelers during the years 1955-1975 accelerated the decline of the bicycle. When sales of mopeds finally fell, the decline mainly benefited public transportation or the car, since bicycles had already become a virtually unheard of mode in the rising tide of automobiles.

A final word on two countries that also saw a major boom in motorized two-wheelers in the post-war years: Italy and Spain. This boom is less related to the desire to motorize cyclists at all costs than to the concern, for fairly poor populations who cannot afford to buy a car, to nevertheless have access to motorization, a classic phenomenon currently observable in Asia.

1.3.3. The automobile finally popular

From its beginnings, the car was seen as an incomparable instrument of freedom. It allows you to move over long distances, anywhere and at any time: it means no longer depending on human or animal muscle energy, escaping the insalubrity and nuisances of dense cities, abstracting yourself from the schedules and stops of public transportation, and avoiding bad weather. However, it is very expensive and is considered primarily for the elite.

After the Second World War, under American influence at its peak, the time has come, on the contrary, for the democratization of the automobile. Everyone now wants to have access to motorization. With the rise in living standards, the car is gradually entering the consumption norm. Its ever more comfortable cabin is seen as a natural extension of the home. Speed is becoming a symbol of modernity and efficiency, a great way to save time and money or, at the very least, to go ever further to access a greater diversity of goods, services or jobs.

In Europe, France will be able to launch itself very early and quickly into this movement. From the end of the 1930s and during the war, Citroën and then Renault developed popular car models such as the 2CV and 4CV, then the R4. They all sold several million units. The French car fleet grew at an average rate of 10% per year, from 2.3 million passenger cars and light commercial vehicles in 1950 to 6.2 million in 1960 and 13.7 million in 1970, a sixfold increase in twenty years (Landry, 1961). The number of cars on the French market increased by an average of 10% per year, from 2.3 million passenger cars and light commercial vehicles in 1950 to 6.2 million in 1960 and 13.7 million in 1970.

Germany is not to be outdone. The Beetle was ready as early as 1938, but its production will only really start on a large scale after the war. The difficulties of reconstruction delayed the diffusion of the automobile for a while. But the Marshall Plan revived production and, from the mid-1950s, motorization of the population became even more rapid than in France.

On the other hand, the Netherlands and Denmark, which do not have a car industry, have a much later motorization rate. Until the early 1960s, the Dutch owned about 2.5 times fewer cars per capita than the French, before catching up significantly. As for Denmark, it introduced a very high registration tax as early as 1924, which multiplied the pre-tax cost by two to almost three depending on the model

1.3.4. America, a source of inspiration

In the post-war growth years, the gradual motorization of society caused a massive shift in opinion in favour of the automobile. It is no longer necessary for its promoters to exert significant lobbying. It is in full agreement with the vast majority of the population that elected officials of all stripes, relayed by technicians, demand without hesitation that the city adapt to the automobile.

Therefore, to cope with rising traffic volumes and increasing traffic congestion, the time has come not to experiment, but to systematically apply the most proven solutions. And, as in many other areas, America is leading the way. Since the mid-1910s and the rise of the low-cost car, the Ford T, the United States has become the Eldorado of the automobile. Before and especially after the Second World War, all top European engineers working in the field of automobiles, roads, and traffic engineering travelled to the United States to visit Ford and General Motors plants, to see the developing highway network, and to learn about early traffic management models

In 1956, the U.S. Congress embarked on a vast highway program when it suddenly voted to build no less than 68,000 km of Interstate Freeway, including in city centres that needed to be "irrigated" and "revitalized". This meant, in short, destroying entire blocks of houses and buildings. In the racist America of the time, the black neighbourhoods and especially the ghettos were the first to be targeted, not without resistance. During the 1960s, demolitions involved about 100,000 inhabitants per year, or more than a million displaced persons in total

Urban freeways are built according to a doctrine developed just after the war by the UK Department for Transport (Dupuy, 1975) The principle is to combine bypasses and radial roads, creating a spiderweb-like network that serves the centre well while keeping through traffic away from the centre. In the 1950s, the first traffic management models appeared in the United States, allowing the supply of infrastructure to be adapted more effectively to demand, without questioning the traffic induced in return by this infrastructure. In the 1960s, throughout Europe, the watchword was to catch up with America in terms of road development, traffic management, and parking organization.

However, as early as the 1950s and 1960s, in the United States and then in Europe, particularly in the United Kingdom and France, voices were raised to denounce the impasses of the "all-car". These voices came not primarily from civil society, but from the most authoritative circles, i.e. the automobile specialists themselves. They are worried about the pollution that, on days of high pressure, when there is no wind, forms a dark cloud over the big cities. They also fear the rapid rise in accidents, including in urban areas, which threatens local life. In 1963, the British commission, chaired by Colin Buchanan, charged with taking stock of the future of the automobile in the city, uncompromisingly noted that the car “threatens the environment in several ways: danger, fear, noise, smoke, vibrations, dismemberment, aesthetic damage” (Bigey, 1971). More serious and less well known: these specialists are concerned about the enormous space consumption required by the automobile on roads and in parking lots, and the inevitable increase in congestion that results. It simply seems impossible to completely adapt the city to the automobile because of the lack of available space.

As early as 1956, Michel Frybourg, director of the very young Road Traffic Studies and Research Department (*Service des études et recherches sur la circulation routière*, SERC), responsible for setting up French expertise in urban travel modelling, was concerned: "Wanting the automobile to provide all travel would lead to the design of a 1,200m-long highway network for major French conurbations, which is of course unthinkable. At that point, there are only freeways and interchanges, there is no city, so there's no point in doing anything" (Baker et al., 1958). At the same time, in the United States, two well-known American architects and planners are reminding us that "if everyone who comes to New York City by public transit were to drive to the city, the entire area of Manhattan south of 50th Street would have to be turned into multi-storey parks Reuben Smeed, a renowned English specialist, confirmed: "If travel in the centre of major cities is by private car, a considerable proportion of the city's surface area must be devoted to traffic and parking (Reigner, 2009). city's traffic and parking system has been a major source of concern for many years.

As for cyclists, few of these specialists are still considering them. When this is the case, it is only a question of keeping them away from car traffic. Colin Buchanan explains: "The conditions that are likely to prevail in the future, as the number of motor vehicles increases, lead us to believe that it will be necessary to divert bicycle traffic to the less congested lanes. In some cases, it may even be desirable to assign cyclists and pedestrians to the same well-subdivided, well-subdivided lanes, especially at critical points where they pass over or under main distributors

1.3.5. The doctrine of adapting the city to the automobile

The expression "everything to the automobile" ("tout automobile") is a French shortcut that has no equivalent in English. It is certainly a simplifying term, but it expresses fairly well the basic idea that all travel problems could eventually be solved by the almost exclusive use of the automobile. The Belgians, Swiss and Quebecers prefer to use the expression "everything to the automobile", which implies more subtly that financing goes almost entirely to the development of automobile use (Thoenig, 1973). In any case, this idea has apparently never really been theorized. While it has been applied in America, European cities are much less amenable to it.

In France, the prestigious *Corps des Ponts et Chaussées* is naturally responsible for developing the doctrine aimed at adapting the city to the automobile. Since 1966, it has been involved in the field of urban planning, thanks to the merger of the former Ministries of Public Works and Construction into the new Ministry of Public Works (Poulit, 1971). The administration then equipped itself with the tools to tackle this new task by drawing inspiration from American work. Formally, within the Roads Directorate, the Urban Division of the *Technical studies service for roads and highways* (Service d'études techniques des routes et autoroutes, SETRA) is in charge of this task. It became the *Center for Urban Transport Studies* (Centre d'études des transports urbains, CETUR) in 1976.

However, French cities are quite different from American cities. It is impossible, due to the lack of available space, to irrigate them solely by car: their historic heart is an untouchable heritage, the centre that concentrates jobs, shops and public services is often very dense and the suburbs are crossed by narrow, saturated radial roads. To adapt this urban fabric to the car, rows of buildings would have to be demolished to widen arteries, new breakthroughs would have to be made in the centres, and entire blocks would have to be razed to make way for highways and their interchanges.

This is why, in 1971, the doctrine led to a compromise, which Jean Poulit, head of the Traffic and Operations Division of SETRA, summarized in a normative discourse aimed at large provincial cities and based on four closely complementary "recommended solutions": the construction of underground or elevated parking lots in the city centre, numerous enough to satisfy demand; the construction of a "large" highway network including "penetrating" and "protective lanes" in the centre, located "at the very edge of the centre" to divert through traffic; the implementation of exclusive right-of-way public transportation on the densest urbanization routes, "above ground in the outlying areas" and "underground in the centre" to avoid taking up too much space for cars while facilitating access for all to the city centre; and the development of a pedestrian sector in the busiest commercial and historic streets of the hypercentre (i.e., the centre of the centre), to strengthen its commercial and tourist activity. In addition, "urban network operating measures" based on a traffic plan and parking organization are necessary to "make the most of the existing road networks.

With hindsight today, this compromise still seems rather "truculent". Nevertheless, it does make a real place for public transport and was generally accepted and applied in the 1970s and 1980s by all the major French cities. It is in this context that one must understand President Georges Pompidou's famous speech to the Paris Region District on November 18, 1971: "There is a certain aestheticism that must be renounced and [...] it is not because we would prevent cars from circulating that we would make Paris more beautiful. The car exists, we have to make the most of it, and it is a question of adapting Paris both to the life of Parisians and to the needs of the automobile, on condition that motorists are willing to discipline themselves (Flonneau, 1999). "He was simply reflecting the dominant opinion of his time and, in the same speech, he also mentioned the very important investments planned in public transport (RER and metro)

1.3.6. Pedestrians and cyclists spread out

In the French compromise, pedestrians and even more so cyclists are largely forgotten. In order to make way for the car, all other users must be removed or confined to spaces reduced to the bare minimum, so as to hinder traffic as little as possible.

As early as the 1950s, pedestrians began to see the width of sidewalks narrowing and rows of trees disappearing. Crosswalks were then limited in number and baffles were introduced to minimize the interference with turning movements of vehicles. In the 1970s, however, "pedestrian zones" were introduced, a kind of Indian reserve limited to a few low-traffic streets in the downtown core. In the Netherlands and Germany, where they were invented, these zones are comparatively much larger. In the cities destroyed by the bombings of 1943-1945, town planners sought to reconstruct the downtown streets and their urbanity. The first pedestrian streets appeared in Rotterdam, Kassel, Kiel and Stuttgart at the end of 1953. At the end of the 1960s, the Netherlands already had about fifteen and Germany thirty-five, while France did not begin this type of development until 1971, with the Rue du Gros Horloge in Rouen (Dubois-Taine, 1997).

The situation is even worse for cyclists: they have been simply forgotten. Although Poulit elaborates his calculations with “an average displacement of 4 km” (Héran, 2003), perfectly feasible by bicycle, the bicycle is never mentioned, even under the name two-wheelers. However, in the early 1970s, it still commonly represented 10% to 20% of all trips. As a result, by the 1960s, most bicycle facilities were no longer maintained and were removed at the earliest opportunity. In the north of France, the bicycle sidewalks in the coronas disappeared with the widening of roadways. Elsewhere, bicycle over widths, which existed on some arteries, are removed to add a lane of traffic. One-way traffic is beginning to be introduced on residential streets to create an additional parking queue.

Here is the overall assessment - concerning the whole of France and not just the towns - drawn up in 1975 by the engineer in charge of studies on cycling at SETRA: “The cycle path program hardly exceeded 80 km of annual development during the period from 1959 to 1968. These undersized, often poorly maintained tracks did not provide the services expected of them, particularly from a safety point of view. Therefore, since 1969, the construction of these runways has generally been abandoned. There are currently 950 km of bicycle paths or lanes, which represents 0.35% of the length of the French road network (this proportion is around 10% in the Federal Republic of Germany)” (Risser, 1985). It should be noted that the German and French road networks are not comparable. There are many more small, quiet roads in France.

1.3.7. Vicious circles

All these efforts to adapt the city to the automobile are proving catastrophic for cyclists. Cycling is the mode of travel whose modal share has declined the most.

Highways, expressways and their interchanges, built right up to the very proximity of the city centre, generate significant severance effects causing detours and isolating neighbourhoods. In Lille, for example, the boulevards that surround the city for 12 km become almost impassable for cyclists and very unpleasant for pedestrians to cross Lille becomes an island again - this is the origin of the city's name - almost inaccessible to cyclists.

Widespread one-way streets and intersections with coordinated traffic lights increase traffic and accelerate vehicle speeds. In the absence of bicycle facilities, the speed differential between motorists and cyclists increases, making cycling uncomfortable and dangerous. In addition, all these one-way streets significantly increase the distances travelled. In a city like Paris, where three-quarters of the streets are concerned, it can be considered that cyclists' routes are extended by about 20%. Finally, the frequency of traffic light junctions requires cyclists to constantly restart. Under these conditions, cyclists find it very difficult to comply with traffic regulations and traffic plans that are clearly not designed for them.

Cyclists - and almost as many pedestrians - find themselves trapped in multiple vicious circles. They are first caught in what can be called the double spiral of road insecurity (Jacobsen, 2015). The growth of car traffic objectively makes walking and cycling more dangerous. Users then tend to overestimate this risk and gradually give up walking and cycling. This leads some to travel by car by increasing traffic and others to find themselves isolated in this traffic, even less visible and more vulnerable. The phenomenon of "parent-taxis" is a striking illustration of this: parents no longer dare to send their children to school on foot or by bicycle, because of the increase in car traffic, and resign themselves to driving them to school by car, thereby increasing road insecurity.

It has been known since 1949 and the work of the English statistician Reuben J. Smeed that the more motorists there are, the fewer accidents they suffer. Since then, this result has never been contradicted, and Smeed's "law" has even proved valid for each mode of travel.

For cyclists and pedestrians, the first work began in the 1990s (Wegman et al., 2012) then researcher Peter L. Jacobsen systematized the analysis in an article published in 2003 (Héran, 2011). The analysis of cyclists and pedestrians was first carried out in the 1990s. Working on data from 68 Californian cities, 47 Danish cities and 14 European countries, he found that the more cyclists and pedestrians there were, the fewer accidents they suffered. For example, it is three times more dangerous to ride a bicycle in France than in the Netherlands.

Jacobsen then estimates that if the number of cyclists doubles, the risk per kilometre travelled falls by 34% and if, on the contrary, it is halved, the risk increases by 52%. In fact, as cycling travel declines, cycling accidents decline at a slower rate and may even increase. Conversely, when bicycle travel increases, cycling accidents do not increase at all as quickly and may even decrease. Therefore, to reduce the risk of bicycle accidents, discouraging cycling is the worst solution; encouraging it is desirable.
The phenomenon can be explained in many ways. First, when there are many cyclists, they become more visible in traffic: motorists better integrate their possible presence and become more cautious. Second, because of their low speed, cyclists tend to slow down traffic. For example, motorists are no longer able to start in a rush at a traffic light intersection when several cyclists have previously crept past them at a stop. Finally, in the longer term, as the number of cyclists increases, traffic calming measures are taken and bicycle facilities are built, helping to make cyclists safer. The following are some examples of the measures taken to reduce the number of cyclists.

Another negative spiral concerns the increase in distances: the growth in car traffic promotes urban sprawl, which increases the distances to be covered, discourages users from using bicycles and leads them to switch to the car. Similarly, the increase in traffic generates various nuisances (pollution, noise, invasion of space) that make bicycle use unpleasant and encourage cyclists to turn to motorized modes, even though they are the source of these nuisances. All these vicious circles are intertwined and mutually reinforcing, residents end up adopting new lifestyles based on car use that are not compatible with bicycle use.

1.3.8. A collapse of utility bicycling

Until the beginning of the 1950's, cycling was still widely practiced throughout Europe. In the 1950s and even 1960s, workers and employees continued to cycle en masse to the factory or office. One witness recalls that in the early 1950s, the Bezons bridge over the Seine River, west of Paris, was jammed every morning by cyclists travelling from the western townships to the many factories in Nanterre and Colombes (as Dr. Ruffier had already noted in 1929). A generation later, almost no cyclists use this bridge, which is now saturated with cars. Another witness tells us that at the beginning of the 1960s, in front of the Merlin Gérin factories on rue des Martyrs in Grenoble, "bunches of cyclists still left the factory every evening and taunted the few motorists who blocked the way. The very first attempt at a household travel survey (EMD), carried out in Rennes in 1960, revealed that 60% of home-work trips were made by two-wheeled vehicles in that city, an unknown proportion of which were made by bicycle. In the same year, the first survey was carried out in the French city of Rennes.

The cities where cycling is going to resist the longest are clearly the working-class cities: Valenciennes, Roubaix, Dunkirk, Grenoble, Strasbourg, Valence or Saint-Nazaire... The results of the oldest EMDs carried out according to a standard methodology reflect this: another 6% modal share for cycling in Lille in 1976, Grenoble in 1978 and Nantes in 1980, 5.5% in Valence in 1981 and even 6.5% in Valenciennes in 1985, 8% in Strasbourg in 1988 and 4% in Dunkirk in 1991. According to a "study carried out in Caen" (without further details): “At the time of leaving the factories, the flow of cyclists is such that no car can pass and the cyclists use the entire width of lane” (Papon, 2011).

Long-term statistics are scarce and disparate, but they all show a collapse in cycling during the 1950s and 1960s and into the mid-1970s. In France, the decline in cycling is probably quite early and rapid. Although there is a lack of data to verify this, a reconstruction of modal shares is available from the recollections of French people recently surveyed by the 2007-2008 national transport and travel survey (ENTD). For example, in the 1940s, 21% of urban trips (including walking) were still made by bicycle, compared with 6% in the 1970s. This collapse is linked to direct competition from motorized two-wheelers, the rapid rise in car traffic, and the extensive adaptation of cities to the automobile. In the United Kingdom, the situation and its causes are very similar, but there is a surprising statistic: the number of .km passengers per mode since 1952, all networks combined. The result: a sixfold reduction in cycling between 1952 and 1973 (from 23 to 3.7 billion passenger-km), while car use increased sixfold over the same period (from 58 to 345 billion passenger-km)

In Germany, this evolution is not much better known than in France, but is probably quite similar: the adaptation of cities to the car is perhaps a little less advanced, but the growth of car traffic is even faster because motorization has hardly passed through the motorized two-wheeler stage. This weak direct competition from motorized two-wheelers probably partly explains why the decline in cycling is much less marked than in France. Nevertheless, in Berlin (3.4 million inhabitants), a historical reconstruction reveals that bicycle use was divided by ten during the years 1955-1974 (De la Bruheze et al., 1999).

In the Netherlands, where some interesting data are available, the decline is also very strong: in twenty-eight years (from 1950 to 1978), the practice is divided by 2,7 (Mom, 2012). But this decline is much later and the starting situation is better (Schuyt et al., 2004). Whereas in the United Kingdom, in 1952, the practice was already in freefall (and probably also in France and Germany), in the Netherlands, it did not fall sharply until 1965. When it is well under way, however, the decline seems just as rapid, with a level of practice halved per decade: from 1952 to 1973 for the United Kingdom and from 1965 to 1976 for the Netherlands. This delay is due in particular to the absence of a national automobile industry in the Netherlands, to the country's density, and therefore to a less urgent need to adapt cities and the country to the automobile (Ligtermoet, 2009). And if Rotterdam is still today the least cyclist city in the Netherlands, it is because it is the first to have been affected by this adaptation, as Europe's leading port forces (Emanuel, 2010). The starting level of cycling in the early 1950s was also generally higher in the Netherlands than in France or the United Kingdom. These differences were to be of great importance when cycling was revived in the 1970s.

In Denmark, a survey conducted periodically at the entrances to Copenhagen's city centre shows an eightfold reduction in the number of cyclists between 1950 and the 1970s. 56 In this case, rail-oriented urban planning, which is very advanced in this city, may also have played an important role in encouraging people living on the outskirts and working in the city to take the train. In Stockholm, the modal share even increased from 29 per cent in 1950, to 2.4 per cent in 1960 and only 0.8 per cent in 1970. 57 Sweden's early and rapid motorization helps to explain such a collapse.

What happened to all those missing cyclists? We do not know precisely but it is likely that many use a moped, at least in France, some a car, moreover as passengers. Others, more numerous, take public transport when it exists and is sufficiently efficient, which is far from being the case in medium-sized cities. Still others find themselves on foot. The alternative is far from always chosen.

1.3.9. A deeply degraded image of the bicycle and the urban cyclist

While in the 1930s, the bicycle was still a symbol of freedom of movement, a constituent of workers' identity, it became, in the 1950s and 1960s, with the rise of motorization, an obsolete, outdated, vulgar, in short, nerd mode of transportation. Access to a motorized mode is now considered as a progress that frees man from the tiresome constraint of pedalling. The car's comfortable interior finally preserves from the rigors of bad weather. Those who continue to ride their bicycles to work or do their shopping are now mocked, considered at best nostalgic or original, at worst marginalized. As early as 1949, in Jour de fête, the maladjusted Jacques Tati left on his bicycle, as if disoriented, after seeing in the cinema how his profession was practiced on the other side of the Atlantic. Little by little, the bicycle was only used in the city by a captive audience of schoolchildren or penniless adults unable to buy a car or even a simple moped. It has become the "vehicle of the poor", a mode unworthy of a modern society, worse, an obstacle to progress, just like the horse was once. The bicycle is now only a child's toy, a sporting leisure activity or a pleasant means of walking reserved for sunny days.

As for the most daring urban cyclists, the systematic adaptation of the city to car travel alone now forces them to be in constant contact with dense and fast traffic, to stop constantly at the increasing number of traffic lights, to bypass the forbidden directions that are now everywhere, to make major detours to avoid major arteries and to cross expressways at the few existing gradients. To reduce these constraints, they naturally come to "burn the lights" (in fact, to consider them as giving way), take the forbidden directions and invest in places away from traffic: sidewalks, pedestrian zones, urban parks... It is obviously the city's adaptation to car traffic - and not some natural predisposition - that leads cyclists to develop uncivilized behaviour and to free themselves from rules that do not directly concern them.

As a result, other users - among them elected officials and technicians - consider cyclists as dangerous delinquents, unable to comply with traffic regulations, crushers of pedestrians, children and the elderly. In an astonishing turnaround, marginalized cyclists have become the scapegoats of dominant mode users, from the first victims of automobile traffic," explains English sociologist Dave Horton. In private conversations, words are never hard enough to nail them to the pillory. In France, this viewpoint is still dominant among police forces, some researchers and even road safety authorities.

1.4. First rebounds in the 1970s

In the post-war years, the vehicle fleet in the most developed countries of Europe grew at an average rate of 10% per year. France, for example, increased from 2.3 million passenger and commercial vehicles in 1950 to 6.2 million in 1960 and 13.7 million in 1970. 3 This very rapid growth alarms experts who advocate the construction of public transportation to avoid thrombosis. For their part, residents exasperated by the nuisance of automobile traffic are expressing their dissatisfaction. The authorities are trying to respond by promoting alternatives to cars, including bicycles. But national policies on bicycle travel are rapidly diverging, as cycling in some countries has already fallen so low that it is difficult to believe in its future.

1.4.1. Streetcar, metro, RER, bus: the revival of public transport

In France, in the 1960s, the situation of public transport deteriorated: the buses that had replaced streetcars were stuck in booming traffic jams and commercial speeds fell. Riders then turned away from buses and switched to cars, further increasing congestion (Bigey, 1971). In the Paris region, investment has been at a standstill since the 1930s. The authorities also realize that some people who are too poor, handicapped or too young to buy a car or travel with one cannot do without public transportation. At the time, it was estimated that about 30% of the population could not do without public transit (Flonneau, 2003). Finally, in urban centres, the car cannot provide transport alone because of the lack of available space. In short, we must resolve to revive public transportation that has been virtually abandoned by the public authorities for a generation. This will be the big deal in the 1960s and 1970s in Paris and later in the provinces.

Several pressure groups were formed. As early as 1967, the Group for the study of modern urban transport (*Groupement pour l'étude des transports urbains modernes*, GETUM) was created and launched the journal Transports urbains, which was rich in technical, sociological, economic and institutional reflections. In Paris, on November 18, 1970, a demonstration in favour of public transport and to protest against the increase in the price of metro tickets brought together between 20,000 and 50,000 people, in response to a call from trade unions and left-wing parties (Bigey, 1993). Later, in 1980, the *Group of authorities responsible for transport* (Groupement des autorités responsables de transport, GART) was created. Its objectives were to bring together elected officials from local authorities in charge of public transport, to lobby the State and European authorities to obtain funding and more favourable legal and regulatory provisions, and to provide a forum for exchanges and expertise.

In terms of accomplishments, the Paris metropolitan area is leading the way. Investment in public transport resumed in the 1960s, then expanded with the gradual construction of the RER network (opening of line A in 1977) and the extension of the metro to the suburbs. A few bus lanes were also built, but only on routes where they did not bother motorists and, in most cases, without protection from illegal parking. But smaller cities were hesitant about the cost.

In 1977, Nantes chose a solution that was three times cheaper per kilometre, by rehabilitating the streetcar, which was modernized for the occasion. A first line was built on an old railway right-of-way, which did not bother motorists much but still made an old expressway project on the edge of the hypercentre, at the foot of the castle, impossible. Subsidies and construction were delayed and, in a city in the midst of construction, the mayor - Alain Chénard, PS - was defeated in the 1983 elections by a list of streetcar opponents. Too far along, the line was nevertheless completed and inaugurated in 1985 in the absence of the new mayor. However, the population was in favour of the streetcar and the building, which curiously allowed work on the second line to begin, was in turn defeated in 1989.

In 1983, not without fierce debate, the city of Grenoble embarked, for the first time in France, on the construction of a streetcar line - inaugurated in 1987 - that really took up space from the car. Once again, it was a success. Then came the second line in Nantes, followed by the A line in Strasbourg, etc. Despite a few twists and turns, the streetcar saga would never end. Bus lanes are also multiplying and are increasingly well protected.

For French cyclists, the return of the streetcar is both good and bad news. Good news, because the return of the light rail system helps to calm car traffic around each line, which can only be good news for cyclists. But it is also not so good news, because this mobilization took place at the start against all other modes. In the 1980s, as we shall see, cyclists were clearly seen by public transport promoters as competitors to be ruled out.

In European countries that have been better able to preserve their public transportation, the question of reviving it is less urgent and attention can be focused in a more balanced way on all the alternatives to the automobile. In the 1960s and 1970s, however, their major concern remained to put public transport underground, as Germany did with streetcar sections in some fifteen cities (Gerondeau, 1969) or Belgium by building a pre-metro - or underground streetcar to be converted later into a metro - in Brussels, Antwerp and Charleroi.

1.4.2. Road investments and their consequences

In accordance with the SETRA doctrine, many freeways or urban expressways are actually built on the edge of the city centre, less than 1 km from the hypercentre: “penetrating” highways sometimes even serve the hypercentre directly. Some hazardous projects were however abandoned under pressure from opponents and, more often, due to a lack of financial means.

Numerous underground parking lots and a few elevated parking lots are also built in the city centre, under the main squares and near the central train stations. Some areas lend themselves to the development of vast free surface parking lots in the immediate vicinity of the city centre: the banks of the Rhône and Saône rivers in Lyon, the banks of the Seine in Rouen, the banks of the Garonne in Bordeaux, the former glacis of the fortifications in Lille, etc. In the land use plans (POS, now called local urban plans, PLU), floor standards for car parking spaces are set for all new buildings.

These road investments have not finished complicating the functioning of the cities concerned. Freeways passing close to city centres attract significant local traffic in addition to through traffic. They become saturated, which leads to very costly major bypass projects that are difficult to contest but which then increase automobile traffic and urban sprawl (Strasbourg, Lille, Lyon, Bordeaux, etc.). Penetrating bypasses bring heavy traffic to the hypercentre, which must then be channeled. Central parking lots also encourage car use.

The implementation of traffic plans is even more systematic (Offner, 1979). They were first tested in Paris in the 1950s (one-way traffic on the Grands Boulevards in August 1951), then in the 1960s in the major provincial cities, and were generalized in the 1970s following the circular of April 16, 1971, which encouraged them, with government funding at the end of the process. The principle is to simplify and coordinate the management of intersections, which implies the generalization of one-way traffic, the limitation of turning movements, the multiplication of intersections with traffic lights and their centralized management by regulation systems. Urban traffic is becoming a pure hydraulic issue. The street is assimilated to a pipe and traffic to a flow. Local life is in fact completely neglected.

The increase in capacity is appreciable: "in the central districts of the conurbations", the traffic plans would have allowed "an increase of almost 40% in capacity accompanied by a significant reduction in journey times. Today, in a city like Paris, three-quarters of the roads are one-way and no fewer than 1,740 intersections are equipped with coordinated traffic lights. Cities such as Lyon or Lille have almost all their arteries one-way with, even today, some green waves set at very high speeds (45 and even 50 km/h).

Like France and the United Kingdom, Northern European countries have adapted their cities to the automobile, but they seem to have pushed the logic a little less far, acted less quickly or reduced the negative impacts: Fewer one-way arteries, fewer traffic lights at intersections, fewer streetcar lines eliminated, larger pedestrian areas, more often preserved and better maintained bicycle facilities, more controlled speeds, as many (or more) bypasses and bypass roads, but more gradient crossings for non-motorized people... This is no doubt due to the reduced power of engineers and the greater role of urban planners, more decentralized decisions, and more critical and attentive populations. It is therefore only a question of degree in the application of policies that are not fundamentally different.

1.4.3. “No more cars!”

In the effervescence of the 1960s, in the midst of economic, social and cultural change, various movements challenging the consumer society emerged. In Amsterdam, in 1965, the protest and libertarian activists of the “Provo” movement made headlines. Among their many often far-fetched and playful “white shots”, they imagined abolishing car traffic and providing everyone with free public white bicycles (witte fiets), a kind of “Vélib” before hour (Sauvy, 1968). The few bicycles that are distributed quickly disappear, but the idea of daring to limit car traffic germinates in people's consciences. In implicit reference to this news, on April 1, 1967, the only French television channel broadcast a hoax in which the reporter "presented the new measures taken by the public authorities with regard to traffic: banning cars in certain districts of Paris in favour of bicycles," with interviews of shared users to back it up (Meadows, 1972). Such a joke shows how far from credible the idea of encouraging cycling is, but it is making progress.

At the same time, a few rare opponents of the all-motor car appeared: promoters of public transport such as Jean Robert or the demographer Alfred Sauvy, who, in Les 4 roues de la fortune, put forward many counter-arguments (Illich, 1973). However, they were in the minority and considered to be backward-looking, at least until May 1968. It was in 1968 that a think tank bringing together researchers - economists and high-level scientists - and industrialists met for the first time in Rome. It was concerned about the consequences on natural resources and the environment of the demography and rapid growth experienced by the Western world. In the early 1970s, the Club of Rome commissioned a report from the Massachusetts Institute of Technology (MIT), which was published two years later under the title The Limits to Growth (Duchemin, 2004).

This report had a great impact: despite strong criticism, the public discovered and retained that natural resources were exhaustible, that the impacts of growth on the environment were considerable, and that it was impossible to continue exploiting the planet in this way indefinitely.

Faced with the flood of cars and the rise in environmental threats, civil society is waking up. In all "developed countries", cyclo-ecological demonstrations are multiplying. The bicycle is becoming the symbol not only of a criticism of the "all-motorized", but also of a contestation of consumer society, of which Ivan Illich will be the tutelary figure. In all the major cities, bicycle defense associations appear and then try to federate.

The energy crisis at the end of 1973 and 1974, which led to a quadrupling of oil prices, suddenly made the public aware of the need to develop alternatives to the automobile. Car-free Sundays, to the delight of cyclists, were hastily organized in many countries: the Netherlands (a faithful friend of Israel, under an oil embargo by Arab countries), Belgium, Germany, Austria, Switzerland, Italy... but not in France. In 1974, René Dumont ran for the presidential election as the first environmentalist candidate and arrived at the bicycle rallies.

1.4.4. The organization of the cycling movement

In 1974, the bicycle defense movement (MDB) is created by Jacques Essel. He protested, in particular, against the verbalization of cyclists using the narrow bus lanes created in Paris two years earlier to cope with increasing traffic difficulties, and banned bicycles. The return of bicycles to the middle of the roadway between the bus corridor and the flow of cars led to the near-impossibility of traffic and their subsequent elimination from the Parisian pavements. Following this protest, the verbalizations stopped and the cyclists were tolerated (but not immediately authorized). It was not until 1999 that certain corridors were officially opened to them and the change in the municipal majority in 2001 that many of them were finally widened.

Also, in 1974, in Grenoble, the association for the development of public transport, cycle and pedestrian routes in the Grenoble region (ADTC) was founded. It campaigns for the return of the streetcar and for urban cycling to "regain its rightful place". On a Saturday in May 1976, 5,000 cyclists marched through the city (Sandels, 1975).

In 1975, the Two-Wheeler Action Committee (CADR) was created in Strasbourg on the initiative of Jean Chaumien. This pastor with a strong personality was to play an important role in the organization of the French and even European cycling movement. In 1980, he helped create the Federation of Bicycle Users (FUBicy, now FUB), which brings together the first French associations of urban cyclists and whose headquarters have been in Strasbourg ever since. In 1982, still under the impetus of Chaumien, its first president, FUBicy joined forces with other national federations to found the European Cyclists' Federation (ECF).

In Great Britain, cyclists find it harder to organize themselves. The London Cycling Campaign (LCC) was only created in 1978 and the Cycling Touring Club (CTC) only really began to defend urban cyclists in the 1990s. In Switzerland, the first association - IG Velo beider Basel (Interest Community of the two Basel) - appeared as early as 1975, but it was not until 1985 that a federation was created: IG Velo Schweiz, renamed Pro-velo in 2007.

In Northern Europe, cyclists are quicker to get together. In the Netherlands, the Fietsersbond (the cyclists' association) appeared in 1975. In the same year, the Belgians founded the Research and Action Group of Daily Cyclists (GRACQ) and its Flemish equivalent, the Onderzoek & Actie van de Fietsers (OAF), which later became the Fietsersbond Vlaanderen. In 1978, the Allgemeiner deutscher Fahrrad-Club (ADFC, club of German cyclists united) was founded in Bremen. In Denmark, the Dansk Cyklist Forbund (DFC, the Danish Cyclists' Association) was founded in 1905 and has always stood up for cyclists.

Protests are multiplying. In May 1975, thousands of cyclists demonstrated in Brussels. On June 4, 1977, as part of a World Day of the Bike, 9,000 cyclists marched in Amsterdam (also a big success in Berlin and Copenhagen). The participants demanded "an immediate halt to the construction of parking lots in the city and the obligation to park cars on the outskirts, more importance given to public transport, a better cycling infrastructure" and "the committee demanded a speed limit of 20 km/h in urban areas". From the outset, the demands were not limited to bicycle facilities. Two years later, the movement joined forces with other associations to launch a campaign to reduce speed limits in the city ("50 is too much") and obtain the generalization of "30 zones".

Other associations - neighbourhood, parents', children's and pedestrians' associations (Appleyard et al., 1976). Historian Philippe Ariès, in a remarkable article, explains how the car gradually drove children off the streets (Loiseau, 1989). California urban planner Donald Appleyard demonstrates in a resounding book, thanks to an in-depth survey of the inhabitants of three San Francisco streets, that dense and rapid traffic destroys neighbourhood relations and pushes families to flee to the outskirts of the city.

But here again, civil society in Northern European countries reacted earlier, faster and stronger than in France. It was in the Netherlands that the protest began. They take seriously the Buchanan report, which advises the creation of "environmental areas" to protect neighbourhoods from the nuisance of automobile traffic. With the support of the residents, they found a testing ground in Delft and, as early as 1968, they created the first "urban courtyard" (woonerf), a kind of street for children where only motorists wishing to access the houses along the river were allowed to drive at very low speeds. After the success of these initial developments, initiatives multiplied, first in Gouda (Loiseau, 1989) and then throughout the country (Monheim, 2000).

Since the mid-1970s, the Germans have also been interested in these experiments and have been calling - via environmental movements and residents' groups - for safer facilities for pedestrians and cyclists, often with the support of the authorities, technicians and academics.

1.4.5. Practice Renewal

Throughout Western Europe, bicycle use began to rise significantly after the 1974 crisis, long before the first government measures could take effect.

In the Netherlands, the decline ended in 1978, and practice increased by 30% in five years. In Copenhagen, data from a survey conducted at the city's entrances indicate an even more marked rebound. In Great Britain, too, there was an upsurge from 1974 onwards. In Germany, the picture is even clearer. From 1976 to 1982, says Heiner Monheim, professor of geography at the University of Trier and co-founder of the ADFC, "bicycle travel increased by 30 percent, despite a steady decline in bicycle travel over the previous two decades. This increase cannot be explained by development efforts during this period of growth. Cycling was rediscovered by the Germans as a useful means of travel before policies and planners began to take action in its favour. Even in cities with poor cycling facilities and a lack of cycling knowledge, cycling use began to grow." (Papon, 2012) Even in cities with poor cycling facilities and a lack of cycling knowledge, cycling use began to grow. The data collected by Adri Albert de la Bruheze and Frank Veraart for nine European cities confirms all these findings

In France, there are no mobility statistics to confirm or deny such a rebound (Stoffers, 2011). But, like everywhere else, bicycle sales skyrocketed: with the help of the energy crisis, domestic bicycle sales rose by 24% between 1973 and 1974, from 1.6 to almost 2 million bicycles. Minibikes, in particular, were a great success. While this growth is no doubt partly due to the boom in leisure bicycles, it is certainly also due to the revival of utility bicycles.

But where do these cyclists come from? The Dutch historian Manuel Stoffers rightly notes that "the revival of bicycle use and the rise of bicycle policies in many Western European countries during the 1970s [were] parallel to the continuous increase in car use" and concludes that the "substitution thesis" between bicycle and car is questionable

1.4.6. The pragmatic response of the Dutch and German authorities

Across Europe, states and many cities are reacting to the new context and the demands of the population by implementing policies in favour of pedestrians and cyclists. But these policies will take quite different forms in different countries.

In the Netherlands, to support city initiatives, the government decided in 1974 to fully fund two "pilot cities" - Tilburg and The Hague - to demonstrate the feasibility of more bicycle-friendly cities, with the creation of priority routes enabling cyclists to access and cross the city in complete safety (Fietsberaad, 2009). In Tilburg (170,000 inhabitants), the results are very encouraging, with more mixed results in The Hague, a large city of 500,000 inhabitants, where the situation is more complex.

In the new cities of Almere and Lelystad, public authorities are developing a new balance between "segregation" and "integration" of cyclists in traffic. On the main roads, segregation is de rigueur with the development of bicycle paths or lanes, while in the heart of the districts, integration - or rather cohabitation as it is called today - is deemed sufficient as long as the speed of vehicles is limited to 30 km/h by road improvements, which makes it possible to avoid the construction of bicycle facilities. Every 500m, footbridges pass over the expressways (Braudel, 1979).

In 1976, a decree officialised the urban courts and there were already 2,700 of them in 1983. But these are expensive and time-consuming to set up. At the request of residents' associations, technicians also experimented with the Zones 30, which were in turn made official in 1983. The general principle is to create - or modernize - bicycle facilities along the main roads and to calm traffic on the service roads. In particular, transit traffic in the hypercentres is suppressed everywhere, as in Groningen since 1977. 36 Parking is also strictly controlled. In order to avoid cuts caused by major infrastructures, graded crossings are systematically built.

In Belgium, the Flemish cities, attentive to the developments of their northern neighbours, are gradually following suit: Kortrijk started to promote school bicycle travel in the early 1980s and Ghent launched an ambitious bicycle plan in 1994.

Several factors explain the pioneering role played by the Netherlands. First, geographical constraints and urban density severely limit urban sprawl and complicate road construction. The sandy and peaty nature of the land means that subsiding pavements have to be regularly resurfaced, which allows for faster development. To facilitate this repair, streets are most often paved with bricks, with a differentiated treatment according to the authorized speeds. For example, in Utrecht, lanes limited to 30 km/h or less are made of red bricks and pavements limited to 50 km/h or more are asphalted. The space becomes very legible.

Another key factor is the age of urbanization. In 1650, half of the two million inhabitants of the United Provinces were already living in cities. This urban culture permeates the entire society. Low-rise houses are built next to each other and face the street on the same level. The doorstep (the stoep) is almost part of the house. The inhabitants have long since appropriated public spaces that are, in fact, semi-private: woonerf, by the way, literally means "living courtyard. They consider that children should be able to play in the street and the absence of curtains on the windows allows them to be watched. They have the right to cultivate a narrow strip of land at the edge of their house, on the sidewalk, for flowers or a few climbing plants. It is easy to understand why there is such a strong reaction when the automobile threatens this way of life.

Finally, many cities are medium-sized, poorly equipped with public transportation, with distances suitable for cycling. In particular, commuting distances are fairly short and, when this is not the case, the density of the rail network makes it easier to complement "bicycle + train". The situation is similar in Belgian Flanders, where local employment is much higher than in Wallonia (Loiseau, 1989).

As early as the late 1970s, in the wake of Dutch innovations, some German cities close to the Netherlands, such as the city-state of Bremen and some cities in North Rhine-Westphalia, such as Münster, or Lower Saxony, such as Buxtehude southwest of Hamburg, began experiments in traffic calming and the revival of bicycle facilities. The German federal government is supporting these initiatives by adopting the "pilot city" approach pioneered in the Netherlands. In 1979, ten cities were chosen to benefit from substantial investments in order to become "bicycle-friendly cities" (fahrradfreundliche Städte). Among them: Erlangen (north of Nuremberg), Freiburg, Heidelberg, Münster, Troisdorf (near Cologne) (Golbuff et al., 2011).

Again, there are several reasons why Germany is so quick to follow the Netherlands. In addition to its geographic proximity, it is also a fairly urbanized country where children are used to playing in the street and where what we call the public space in France is more commonly referred to as the residential environment: "The street, especially the sidewalk, is an extension of the home. 39 "The weight of urban planners is also more important here. While in France, in 1966, the Ministry of Construction was absorbed by the Ministry of Public Works to create the Ministry of Public Works, to create the Ministry of Public Works, under the authority of the Corps of Civil Engineers, in Germany, the Ministry of Construction remains dissociated from the Ministry of Transport and supports all initiatives in favour of traffic calming. The associative sector is also more organized and more powerful than in France.

This pragmatism makes it possible to learn little by little the subtle articulation between various types of cycling facilities and traffic calming. Indeed, the problem is not just about creating bicycle paths in the middle of the city. In most cases, there is not enough space for such facilities, and reintegrating cyclists at crossroads is difficult and dangerous. It is often better to create simple bicycle lanes on the main roads or even reduce speed enough so that everyone can live together without the need for specific facilities.

Other innovations were already emerging at this time. Counter-cycling in one-way streets is being tested in pilot cities in the Netherlands. They prove to be very safe because cyclists and motorists see each other when they pass each other. As a result, they were introduced nationwide in the late 1970s. Likewise, opening bus lanes to bicycles poses little difficulty for bus drivers while at the same time making cyclists very safe. The airlocks at intersections are also simple to build and make cyclists more visible, especially those who want to turn left. Authorization to turn right at traffic lights was obtained later, in 1991.

1.4.7. The ultraliberal response of the British authorities

As elsewhere in Western Europe, the United Kingdom experienced a remarkable utility bicycle boom until the early 1950s. But the reconstruction of cities destroyed by the war was an opportunity to push their adaptation to the automobile quite far, like the American cities that serve as a model here more than anywhere else in Europe. Coventry, a city razed to the ground by Nazi bombing in 1940, is the best illustration of this: a highway ring road only 3.6 km long and numerous parking lots surround the city centre, not without creating a major disincentive for cyclists. In 1963, the Buchanan report did, as we have seen, propose the creation of "environmental zones" to protect neighbourhoods from invasive traffic, but these recommendations were not implemented, since Transport Minister Ernest Marples, who commissioned the report, was hostile to them. Before his appointment, Marples ran a road construction company and had to sell his shares to avoid a conflict of interest. But it was later learned that he had sold them to his own wife, which caused a scandal.

In this context, the rise in car traffic and the concomitant fall in bicycle use are all the more marked. With the energy crisis of 1974, there were calls for action, but the government procrastinated. Should we revive a mode of travel considered dangerous? How can bicycle paths be created everywhere? Isn't it the responsibility of local authorities?

The arrival in power of Margaret Thatcher in May 1979 and for eleven and a half years put an end to these hesitations. Faced with very high unemployment and the perceived excessive cost of railways and public transport, the time had come to develop the road network, privatize the railways and deregulate bus and coach services (which were very popular in the country). According to the government's 1989 White Paper, the aim was to carry out "the largest road building program for the United Kingdom since the Romans": 24,000 miles - or nearly 40,000 km - were inaugurated between 1985 and 1995. The line is clear: “roads for prosperity” to build “a great car economy”. For bicycles, only the separation of traffic was envisaged and, to keep the unemployed occupied, bicycle paths were built on certain disused railroad tracks (SETRA, 1974).

This policy of unqualified encouragement of car use was also found in Italy and Spain in the 1970s and 1980s. However, for these two countries, the aim is to catch up with their lag in motorization in Europe. Cycling is their last concern, except in a few rare cities in Northern Italy: Ferrara and Bolzano in particular, we will come back to this.

1.4.8. The inconsistent response of the French authorities

In France, the systematic adaptation of cities to the automobile has been underway since the end of the 1960s, under the central authority of the Ministry of Public Works. In the context of the energy crisis of 1974 and under the pressure of the demands of pedestrians and cyclists, SETRA tried to adapt its discourse and wrote three edifying guides devoted to “light two-wheelers” (bicycles and two-wheelers under 50 cm3, pedestrians and urban roads. They are intended to take into account all users (SETRA, 1974).

However, to preserve at all costs and even facilitate car traffic, only the separation of traffic is really recommended. The overriding needs to organize traffic, to avoid points of conflict as much as possible, to provide maximum safety and to give each traffic a speed consistent with its needs, led to the notion of traffic separation, notes SETRA in 1974. In theory, each type of traffic could have its own network. It is implicitly considered normal for motor vehicles to be able to travel rapidly in cities, with a speed limit of 60 km/h in urban areas since 1969.

However, SETRA recognizes that this segregation cannot be generalized: "The strict application of this principle, which is not new, to all flows, leads to complex solutions which, in any case, are not possible in the existing fabric in a systematic way. What is more, the interpenetration of flows is inevitable at certain points; it is then important to manage conflicts. 45 But, in fact, the pedestrian guide, published in 1975, recommends above all uneven crossings to avoid interrupting the flow of cars: "Crossing on the surface is generally faster. It must therefore be made impossible for pedestrians to cross over obstacles by installing protective barriers on each side of the graded crossing if they are to use it only defends the bicycle lanes in order to clear the roadway for the benefit of the car (Julien, 2000). The cover of this guide is also decorated with a sign that says “bicycle lane mandatory”. This document has "been widely distributed and has served as a reference for technicians in both cities and the Equipment Department for more than ten years

The same year, the Minister of Public Works, Robert Galley, published a circular aimed at promoting energy-efficient transportation, especially bicycles: "The energy crisis, the fight against waste, and the need to design and develop more humane cities have led us to take a fresh look at the design and operation of our transportation system, giving priority to modes of transportation that consume the least energy, such as public transit and bicycles and mopeds. Then, to help cities build the recommended bike paths, it appoints a bicycle correspondent in each of the seven centres for technical studies of equipment (CETE) located throughout France.

From the outset, the State has occasionally financed certain bicycle facilities and a few initiatives. Thus, on August 14, 1976, the city of La Rochelle made 250 yellow bicycles available to the population free of charge, with their purchase subsidized by the State at 60%. The use of these bicycles was free from 8 a.m. to 8 p.m. All you have to do is borrow one and then return it to one of the twenty-three places scattered around the city centre, especially near the parking lots, just like a supermarket cart. The media impact of this initiative is considerable, both in France and abroad, but the bikes are proving to be too weak and thefts are on the increase.

In December 1977, the Ministry systematized the co-financing of bicycle paths by deciding to subsidize their construction at a rate of 50% in urban areas and 85% in rural area (Héran, 2000).

Destabilized, several cities that had begun a policy of bicycle development at the end of the 1970s, taking advantage of government subsidies, slowed down or abandoned their investments. This is notably the case in Bordeaux, Grenoble and Lille. Strasbourg is the only city to have continued its investments.

1.4.9. Discontinuous networks

Two methodological problems will be added to the mistakes made by the State and cities: in the design of bicycle networks and in the understanding of safety issues.

The SETRA bike guide recommends to ride only on tracks and to avoid strips that were wrongly considered too unsafe at the time. There is no intention at all to moderate speeds to encourage cohabitation: speed in the city is still untouchable. This point of view was widely shared at the time. Even Christian Gerondeau explains in his book "The useless death", published in 1979: "Since the majority of victims are killed or injured in collisions with cars or trucks, efforts should be made to reserve special lanes for bicycles, separated from car traffic. These can take different forms, depending on whether they are lanes along roads open to general traffic or completely separate routes. "

In practice, trails should be developed where there is a high flow of cyclists, safety concerns and sufficient space (implied: so as not to hinder motorists). In this game, the resulting network can only be discontinuous. As soon as the road network becomes narrower, as soon as a junction is congested, the bicycle paths stop upstream. As a result, isolated stretches of track are scattered throughout the urban areas.

In new cities - such as Villeneuve d'Ascq or Marne-la-Vallée - which have attempted to create a bicycle network that is entirely separate from the automobile network from the outset, cyclists find themselves forced to make various detours and extra efforts to cross arteries through uneven passages - when there are any - and are unable to memorize such a complex and unreassuring network at night. Moreover, when they are forced to reintegrate into the general traffic at the entrances and exits of the bicycle network, the motorist has had time to forget about them and finds himself very surprised to encounter them.

These pseudo-networks are proving to be unusable for cyclists, who are constantly coming up against untreated difficulties: dangerous crossroads, radial junctions or boulevards without any development, cuts linked to highways and urban expressways... As a result, cycling continues to decline inexorably. Seeing very few cyclists on these tracks, and with good reason, many technicians and elected officials end up considering that these investments are simply useless and lead to a waste of public funds.

An overestimated risk of bicycle accidents

As we have seen, France is the only country in Europe with more motorized two-wheelers than bicycles, due in particular to the phenomenal success of mopeds. In scientific and technical circles, at conferences and in publications, the word "bicycle" has even become taboo. It is now necessary to say or write "light, non-motorized two-wheelers", a euphemism that today seems ridiculous but which meant that mopeds should not be forgotten. However, the amalgamation of the various types of two-wheelers has the unfortunate consequence of greatly overestimating the risk of bicycle accidents. Motorized two-wheelers are much more vulnerable than bicycles because they are both heavier and faster.

At the beginning of the 1990s, inspired by German work, CETUR demonstrated this by calculating the risk of travelling in an urban environment according to different modes of transport. Thus, in 1990, in the Strasbourg conurbation, for a risk 1 of being killed or seriously injured while travelling by car, the risk is 2 on foot or by bicycle, but 17 on mopeds and more than 50 on motorcycles. (Ziv et al., 1981) The risk of being killed or seriously injured while travelling by car is 2, but 17 on mopeds and more than 50 on motorcycles. The risk of being killed or seriously injured while travelling by bicycle is 2, but 17 on mopeds and more than 50 on motorcycles. 58 This type of difference is found in almost every city in France and is not changing much

Unfortunately, the distinction between bicycle and motorized two-wheeler risks comes late because, since the 1970s, Road Safety has published alarming figures on “two-wheeler accidents” (bicycle and motorized two-wheeler accidents combined. In 1976, out of 5,000 deaths in traffic accidents in urban areas, 30% were two-wheelers, recalls a CETUR report, for example. (Horton, 2012) “In 1976, out of 5,000 deaths in traffic accidents in urban areas, 30% were two-wheelers”, recalls a CETUR report. This statistical confusion reinforces the conviction of most technicians that “cycling is dangerous”. Many have come to recommend to their elected officials that they no longer build bicycle facilities so as not to encourage this mode of travel. This confusion is still present today in some results.

Now subject to the pressure of car traffic, the bicycle is certainly no longer the quiet mode of transport it was before the war. But with the most vulnerable having given up cycling and the most seasoned doing their best, the objective risk - as statisticians measure it - has not exploded. On the other hand, the subjective risk - as perceived by the population - has become considerable: potential cyclists feel strongly threatened. Parents no longer dare to let their children ride their bicycles on the street, adults themselves fear for their integrity and no longer imagine riding a bicycle.

The belief that urban cycling has become a very vulnerable mode of travel has important and paradoxical consequences, which have been well analysed by British researcher Dave Horton, who identifies three. Above all, cyclists should be educated to be cautious and to respect the rules. Next, helmets should be made mandatory, and finally, cyclists should simply be separated from traffic to keep them safe. In short, all of these seemingly common-sense measures actually reinforce the idea that cycling is a very risky mode of travel and end up discouraging its use, rather than encouraging it. While we should not, of course, renounce any recommendation or safety device, a more balanced treatment of the subject is, to say the least, necessary.

As early as the 1930s, edifying pamphlets warned children and adults about uncivil behaviour. We see cyclists zigzagging between cars, riding head-on, running red lights, speeding through forbidden directions, shamelessly shoving pedestrians... The behaviour of motorists, much more dangerous, is never reported: No skimming overtaking of cyclists at high speed, no fishtailing, no changing direction without flashing lights, no surprising honking of the horn or roaring of the engine, no untimely opening of the door... If cyclists get run over, it is entirely their fault. If cyclists are run over, it is entirely their fault. The overthrow is complete: whereas motorized modes, by the danger they engender, are the main cause of cyclists' setbacks, it is the latter who are now designated as guilty and subjected to moral redress. Cyclists obviously find it very difficult to bear the discrepancy between their daily realities and these injunctions, which are consequently ineffective.

1.5. European divergences in the 1980s and 1990s

The 1980s and 1990s will prove to be decisive: utility bicycle practices begin to differ from one European country to another. While trajectories had hitherto been fairly parallel, despite some differences, some countries or regions, such as the Netherlands, Germany, Denmark, Flanders, German-speaking Switzerland and Northern Italy, managed to halt the post-war collapse and even to turn the situation around on a lasting basis; others, such as France, the United Kingdom and Spain, on the contrary, saw the use of utility bicycles start to decline again until they became confidential. What happened? Traffic calming policies seem to have played a key role.

1.5.1. Traffic calming in Germany

At the end of the 1970s, under the influence of the Netherlands, Germany embarked on a policy of Verkehrsberuhigung (literally "traffic calming"). The three city states of Bremen (550,000 inhabitants), Hamburg (1.8 million inhabitants) and Berlin (3.4 million inhabitants), as well as the state of North Rhine-Westphalia (17.8 million inhabitants with the cities of Cologne, Dortmund, Düsseldorf, Münster...) are at the forefront of innovation.

Three generations of traffic calming will quickly follow one another. At the end of the 1970s, under the influence of the Netherlands, Germany and the Nordic countries, experiments with calm streets multiplied: city courtyard, street limited to 30 km/h, street with priority for cyclists (Fahrradstraße). In the 1980s, entire districts moved to zone 30 with reduced transit, such as Charlottenburg and Kreuzberg in Berlin or the Neustadt in Mainz. Finally, in the 1990s, entire conurbations became "30 cities" by extending Zone 30 to all service roads. As early as 1983, Buxtehude (40,000 inhabitants), 20 km southwest of Hamburg, was the first to move its streets entirely into zone 30, except for the main roads. Bremen, Hamburg and Berlin gradually followed suit. In 1985, a major conference in Berlin took stock of the advantages and disadvantages of the experiments underway and the progress that could be made.

In the heart of quiet neighbourhoods with reduced transit, cyclists do not need cycling facilities. This is a major simplification for users and technicians alike and a substantial saving of space and resources. All efforts can then be concentrated on major roads that are gradually being systematically equipped with bicycle facilities, to the detriment of the width of the roadway reserved for motorists. The effort also covers the entire city, including the outskirts and not just the centre. Land cuts related to major rapid transit infrastructure are also being addressed through grade separations or requalification as urban boulevards.

For example, in Düsseldorf (550,000 inhabitants), the B1 urban expressway (50,000 vehicles per day) along the Rhine cut off the city centre from its access to the river. Its 1.9 km underground construction, carried out in the early 1990s at a cost of some 200 million euros, was justified solely by the desire to reclaim the banks and moderate traffic in the depths of the surrounding urban fabric. The infrastructure remains at 2 × 2 lanes, the speed in the tunnel is deliberately limited to 60 km/h to control time savings, and the number of entrances and exits is sharply reduced to avoid an influx of traffic into the city. All this makes it possible to transform many streets in the centre of the city into traffic calming zones. (Bonanomi, 2000)

In a country where the automobile lobby is very powerful, traffic calming obviously arouses strong opposition. To reduce the opposition, the method always consists of proposing an experiment, with the possibility of going backwards if the results are not up to scratch. Before and after studies are always carried out. As they always show that the results are positive on almost all levels, the zones 30 are almost never questioned. In the rare cases where this is the case, a compromise is to create zones 40.

The results of traffic calming policies are still very positive: a sharp drop in the most serious accidents (from 20% to 30%), a significant reduction in nuisances, and a modal shift from cars to other modes, especially to bicycles. The only downside is that motorized vehicles lose a little time, but much less than they initially feared: although the speed limit has been lowered from 50 to 30 km/h, a 40% drop, the average speed is only about 10% lower in off-peak hours and even less in rush hour (Bracher et al., 1988).

In 1988, the German researcher Tilman Bracher, in a study on bicycle policies in Europe, concluded in no uncertain terms: "Good bicycle facilities alone are not enough to get motorists to start cycling. Research in Delft, Graz, and the German cities of Buxtehude and Rosenheim has shown that extensive traffic calming and parking restrictions are essential".

1.5.2. Limited traffic areas in Italy

In the Po plain, protected from westerly winds by the Alps, pollution easily accumulates in traffic-saturated city centres, especially under the arcades. In order to save the historic buildings eaten away by pollutants, pacify the centre and revive tourist activity, some cities, such as Ferrara at the end of the 1960s, established a zona a traffico limitato (limited traffic zone). Following their success, the ZTLs multiplied and the law of March 24, 1989 made the concept official. The idea was to prohibit access to cars in the centre, with the exception of the inhabitants of the zone, emergency services, public services, the handicapped, public transportation, cyclists (but not motorized two-wheelers), cabs, delivery men, craftsmen, garages, hotel guests, hospital patients, etc. The law also forbade the use of vehicles in the centre. In practice, these many rights holders represent only 10-20% of total traffic and the speed limit in the zone is often 30 km/h. “This regulatory measure does not require any special arrangements for public spaces. Only zone entrances must be marked and signalled, indicating authorized traffic, schedules, etc” (Lieutier, 1997).

In the 1980s and 1990s, dozens of Italian cities developed a ZTL, such as Bolzano, Mestre, Padova, Florence, Bologna, Pisa, Parma, Modena, Ravenna, Livorno, etc. Thanks to the calm traffic, cycling is taking off (note 5.12). In response to this new craze, many cities have created bicycle paths or lanes along the radial roads leading to the centre. For example, in Livorno (160,000 inhabitants), "the bicycle represents [in 1998] 11.8% of trips, compared to 6% in the 1991 census and 2.3% in 1981

Ferrara (130,000 inhabitants), the most cycling city in Italy (along with Bolzano), is a bit of a special case. For aesthetic reasons, the city closed its historic centre to car traffic and motorized two-wheelers at the end of the 1960s (PREDIT, 2001). Its bus network is also poorly developed. In 1995, the city was selected as a UNESCO World Heritage Site. Realizing the importance of its modal share of cycling, it declared itself the "città della biciclette", launched a Bicicard for tourists, allowing them to leave their cars at the entrance to the city and rent a bicycle to visit it, and then, in 2000, a Biciplan to develop radial roads, deal with dangerous intersections and crossroads, increase the number of parking arches, etc. In 2008, the modal split was 56% car, 3% 2WD and 1% cab (total 60%), compared to 27% bicycle, only 8% walking and 5% public transport (total 40%) (Héran, 2013). The modal share of the car obviously remains very high in the outskirts, where traffic has not been calmed. And the growth of cycling seems to have been mainly to the detriment of walking.

The Italian example is yet another demonstration of the crucial role of traffic calming in the revival of utility cycling. However, ZTLs can sometimes lead to a modal shift to motorized two-wheelers, as in Pisa and Parma, ruining the hope that the area will also benefit public transport.

1.5.3. Attempts to moderate traffic in France

In 1982-1983, the Ministry of Public Works launched the "React" and "Target minus 10%" campaigns to reduce accidents, initially focusing more on road safety than on development. Then, in 1984, CETUR decided to launch the "Safer City, Accident-Free Neighbourhoods" program, proposing that many communities experiment with new types of traffic calming measures inspired by the Dutch and German experiences, evaluate them and disseminate the most convincing solutions. All these experiments and the lessons to be learned are described in two thick, rich books (CETUR, 1991).

As part of its road safety policy, the government reinforced these experiences by deciding, in 1990, to lower the speed limit in cities to 50 km/h - 33 years after Germany did so on September 1, 1957 - and to introduce the 30 km/h zone in the highway code. The CETUR accompanies this evolution with various documents. But cities are not rushing to use these new tools. Zone 30 areas are progressing slowly and are often poorly designed, too small in size, or even limited to one street, without sufficient speed moderation facilities, both at the entrance and in the zone (Beaucire, 1997). Departmental public works departments and general councils - dominated by rural elected officials because of the electoral boundaries - are opposed to their implementation on major urban roads, even when these roads cross shopping streets or historic centres with intense local life.

The situation is not so bad, however. While it is true that it is difficult to make progress in the districts of Zone 30, in the city centre, on the contrary, major efforts are being made to reclaim public spaces thanks to the gradual arrival of the streetcar and the popular success that accompanies it. Three cities are leading the way. In 1985, Grenoble was the first French city to dare to use the streetcar to really make room for the car, with the elimination of all traffic in a few busy streets in the city centre. In 1991, to make room for the streetcar line 2, Nantes dared to reduce the eight traffic lanes on the 50 Hostages route to just two lanes plus a bus lane. In 1992, Strasbourg, to make way for its first streetcar line in the hypercentre, eliminated the transit of 50,000 vehicles on the north-south axis. The streets and squares along the lines were completely redesigned. The virtues of the "urban streetcar" (Hecker, 2007) are now being talked about. Many cities then rush into the breach. Bordeaux, for example, after endless hesitation, finally opted for the streetcar in 1996 and built three lines at once. Cyclists naturally take advantage of these calm centres, but not right away, as they are initially challenged by the streetcar's appeal to the most vulnerable cyclists: women and teenagers. The cases of Nantes and Strasbourg show this very well.

The case of the agglomeration of Dunkirk (200,000 inhabitants) is particularly instructive. It is one of the few cities in France that has built a 170 km network of cycling facilities worthy of the name and properly maintained. But it has never really sought to moderate car traffic. It is easy to get around by car, parking spaces are abundant and the authorities are accommodating with regard to illegal parking. Nor does the city have a streetcar that could take up some space for the car. As a result, there are few cyclists in the city: their modal share is currently stagnating at around 2% to 3%.

1.5.4. Reasons for policy differences in France and Germany

Several factors explain the ability of Germany, unlike France, to fully address the issue of traffic calming. First, Germany is a federal country, where the Länder (the Regions) have retained a high degree of autonomy and financial power that the French Regions, created by the decentralization laws of 1982, do not have at all. For example, the Land of North Rhine-Westphalia, despite undergoing industrial conversion, has the means to largely co-finance the bicycle-friendly cities program. German cities are also much richer and more powerful. Thanks to the 1973 municipal amalgamation, their territory is quite large, which favours more coherent travel and urban planning policies. In France, intermunicipal cooperation is progressing much more slowly and responsibility for transportation and roads is still often left to the municipalities. In Germany, the accumulation of mandates is much more limited, which allows the mayor to be more attentive to the population and more aware of issues. Finally, Germans have a higher standard of living than the French, which makes them more demanding in terms of quality of life.

Germany is then a country where environmental concerns are long-standing and well rooted in civil society. It is the cradle of ecology and of the first Green Party (Die Grünen founded in January 1980). The question of nuisances, with the threat of nuclear power, pollution or acid rain, preoccupies the population, who demand action. Non-motorized modes of transport are more easily popular.

Finally, without reaching that of the Netherlands, Germany's population density is double that of France. As a result, the control of urban sprawl is better understood, which is rather favourable to the use of bicycles. Germany is also a country with a longer history of urbanization than France: the urban population has been in the majority there since the beginning of the 20th century. It is still a much less centralized country, with a dense network of medium-sized cities that are more conducive to cycling (such as Münster or Freiburg), because the distances to be covered and competition from public transportation are less.

1.5.5. Successes and failures of cycling city policies

During the 1980s, the cycling city policies launched in the late 1970s had very different fortunes in different countries.

In the Netherlands, the turnaround was spectacular: +30% in bicycle trips from 1978 to 1985. This recovery was reinforced by progress in traffic calming, which, by reducing vehicle speeds, greatly reduces the risk of accidents. As the number of cyclists increases again, a virtuous circle is set in motion thanks to the phenomenon of safety by numbers. Improved cyclist safety, in turn, encourages new users to take up cycling. In the city of Amsterdam (800,000 inhabitants), the modal share of cycling increased from 21% in 1988 to 28% in 2006

In Germany, from 1972 to 1995, the overall increase was 50% in urban areas. In 16 years, Munich (1.4 million inhabitants) managed to increase the modal share of cycling by 2.5 times and that of public transport by 1.3 times, to the detriment of walking, but also of cars and motorized two-wheelers. The same trend can be observed in Freiburg im Breisgau (220,000 inhabitants), which almost doubled the share of cycling in the total number of journeys within the municipality in 17 years, from 15% to 28%. The same trend can be observed in Erlangen (100,000 inhabitants), Bavaria, where the modal share of cycling has increased from 14% in 1974 to 30% in 1993.28 The closure of the 50 hectares of the historic centre to car traffic in 1973 was a major turning point for the city.

Another example is the medium-sized city of Troisdorf (70,000 inhabitants) in North Rhine-Westphalia, which managed to increase its bicycle modal share from 5% in the 1970s to 21% in the late 1990s

It is unfortunate that in these German cities, the use of bicycles seems to develop mainly to the detriment of walking. Two remarks on this subject. The cyclist has a much greater freedom of movement than the pedestrian: it is not negligible to be able to cover a space twelve times larger with the same muscular energy expended. The rise of the bicycle cannot be dissociated from the rise of public transport and the decline of the car: it is the whole of travel that is being recomposed and it cannot be said that the new cyclists are all former walkers.

In Copenhagen (1.2 million inhabitants), the city managed to quadruple the number of cyclists entering the city during the morning rush hour between 1975 and 2005. This feat is linked to the city's serious financial difficulties in the 1970s and 1980s: due to lack of resources, it gave up many road investments and chose to relaunch cycling (Emanuel, 2010). In Stockholm (800,000 inhabitants), the modal share of the bicycle, which had fallen to less than 1% in the 1970s, rose to 4% in 1991 and 10% in 2006

In the United Kingdom, on the other hand, the practice having fallen very low as early as 1973, the hesitations of the 1970s - should we revive a mode deemed dangerous? - and the Thatcher government's policy of giving priority to the automobile did not really help to redress the practice, which, after a few ups and downs, is now down to around 1% of the modal share.

In France, the results of "household travel surveys" are all too clear. In all cities without exception, even in Strasbourg (see box, p. 123), the proportion of trips by bicycle continues to decline inexorably. In Grenoble, for a while, it was thought that the practice had resumed, but the results were within the margin of error of the results, which is not small when it comes to low modal shares and a mode that is sensitive to weather conditions on the days of the survey. Against this backdrop of persistent decline in the practice, no one believes in the future of the utility bike, a mode deemed outdated, dangerous and doomed to disappear. The best-intentioned imagine at most a future for bicycles in “suburban housing estates” or in summer in seasonal cities. It was not until the 2000s that the practice began to recover.

1.5.6. Difficult relations between public transport and cycling

In France, the 1970s and 1980s finally sounded the death knell for public transportation. With the failure of the first policies to revive cycling, researchers specializing in urban transport, such as public transport operators and the *National Federation of Transport Users* (Fédération nationale des usagers des transports, FNAUT), who were fighting their battles, came to think of cyclists as competitors to be discarded. It is true that, in a context of rapid growth in car traffic, public transport and cycling can only compete directly with each other. 35 Conflicts are multifaceted.

Cyclists would consume excessive space, especially in parking lots. This reasoning, initiated in the 1970s, was based on the confusion, common at the time, between cyclists and other two-wheeled vehicles. 36 A bicycle actually takes up half as much parking space as a motorized two-wheeler because it is smaller and more easily manoeuvrable, and even four times less when bicycles are stored on two levels, which is impossible with motorized two-wheelers. This is why, in the most cyclist countries, the parking of the thousands of bicycles that crowd around the busiest train stations is increasingly rationalized. In Germany, for example, the state of North Rhine-Westphalia embarked in 1995 on a program to build 100 bicycles, at a cost of 1 million euros per unit. In Utrecht, the Netherlands, the city is currently developing 33,000 bicycle spaces around the train station, including a three-story underground parking garage with 12,500 spaces. However, such a financial effort is much less than if it were necessary to invest in parking lots or buses serving the station.

The use of bus lanes by cyclists would be a major hindrance to buses. Operators demand that these corridors, obtained with great difficulty from the 1970s onwards, be strictly reserved for buses. For a cyclist, however, it is much more dangerous to travel stuck between a car stream on the left and buses running on the right. After several studies showing that cyclist traffic in the corridors only slightly slows down buses and at the pressing request of urban cyclists' associations, bus corridors are gradually being opened to cyclists (from 1988 in Annecy and Rennes, in 1995 in Lille, in 1999 in Paris, but still very little in Lyon, etc.), making every effort to widen them as much as possible so as to make it easier for buses to double the number of cyclists (Frenay, 2001).

Transporting bicycles on trains, subways and streetcars would delay trains and would even be dangerous for users. The criticism is admissible at rush hour: the embarkation and disembarkation of many bicycles can cause delays and, in the event of a sudden stop, if there is no space for bicycles, a risk of injury to passengers is possible. However, at off-peak times or in lightly loaded trains, these arguments no longer hold water. On the other hand, accepting the transport of bicycles can be a valuable service to cyclists. Public transport companies will eventually accept it, first in the TER trains operated by the Regions, then in streetcars, generally outside rush hours. Trains are then fitted out accordingly, but, for obvious reasons of space, it is impossible for too many passengers to adopt this system. For this reason, railway companies - in the Netherlands, Denmark, Germany or Switzerland - encourage the creation of bicycle parks at departure and arrival points and the hiring of bicycles at central stations.

Finally, "bike-pool transportation" intermodality would not really have a future. On the other hand, everywhere in France, the authorities are ready to invest heavily in park-and-ride facilities (for cars), without questioning the relevance of such a solution. However, park-and-ride facilities are contested in Northern Europe, Central Europe and the United Kingdom. They take up a lot of space in places that are very well served by public transportation and are best urbanized through real estate projects that combine shops, services, activities and housing. 41 They are very expensive in terms of investment and operation for a small customer base (a maximum of 6% of users of provincial metro and light rail lines in France). They certainly avoid bringing cars into the city, but in dense urban areas other vehicles tend to take up the space that is freed up. Finally, they encourage urban sprawl by making it easier to use cars on the outskirts of the city

A rejection of bicycles by school transportation organizers

Middle and high school students should normally be heavy users of bicycles, a great way for them to gain independence and get active, while riding at a lower cost. However, families and communities are not prepared to encourage them to do so, as evidenced by the case of school transportation.

In the 1950s, against a backdrop of rural exodus and population growth, the State rationalized the school offer by closing classes with small class sizes and, in compensation, offered aid to pupils who had to use school transport (decree of 4 September 1953). In 1958, the transition from compulsory schooling to 16 years of age led to an explosion in the number of pupils transported, which exceeded one million ten years later and reached nearly 2 million in 1980, a figure that has since stabilized. Since school transport is a consequence of school mapping, "it is the responsibility of the state to ensure equal access for all children, wherever they live", according to parents' associations and the National Association for Educational Transport in Public Education Anateep), which since 1964 has been the umbrella organisation for school transport organisers. 43 But the state is unable to manage the thousands of existing routes efficiently and can only imagine chartering more and more buses, leading to a huge waste (price agreements between transporters due to the lack of competition...)

Following the decentralization laws of 1982, responsibility for school transport was transferred to the departments and agglomerations. The urgent need is to regain control of the management of the sector. It is far too late to imagine that secondary school students can travel by bicycle all the way to school or that they can fall back on more direct bus routes: the bicycle has already become marginal and, above all, is considered far too vulnerable.

Since then, two major strategic options taken by both the parents' associations and Anateep have made any initiative aimed at restoring a certain place for bicycles in school trips particularly complicated. On the one hand, following several dramatic bus accidents at the beginning of the 1980s, the safety of students was set as an absolute objective. On the other hand, free school transport was gradually being granted by many departments and urban communities for social reasons or for reasons of territorial equitybuses running almost empty. In addition, Anateep believes that the distance thresholds for subsidy should not exceed 3 km and should be reduced. In such a context, using a bicycle can only be judged, by families, to be both dangerous and expensive, if not useless. The autonomy and physical exercise that this active mode promotes are completely ignored. Many local and regional authorities prefer to invest in school bus lines rather than bicycle facilities.

Anateep has recently admitted that pedi-buses or bicycles - or school transport on foot or by bicycle - can be useful, but it “will nevertheless be extremely vigilant about the precautions that should be taken for [their] organization”. Anateep has recently admitted that pedi-buses or bicycles - or school transport on foot or by bicycle - can be useful, but it "will nevertheless be extremely vigilant about the precautions that should be taken for [their] organization. And she doesn't envision teenagers riding bicycles alone, let alone over distances of more than 3km.

1.5.7. Merchants obsessed with cars

Mass distribution is a French invention of the 1950s. It is based on the American model of the self-service specialty store located on the outskirts of town and accessible by car, and adds the principle of "everything under the same roof". During the 1960s, in Dayton (Ohio), the entire French business elite attended the seminars of a certain Bernardo Trujillo, a sort of guru who theorized the principles of modern mass retailing. Some of his slogans have become famous: "No parking, no business" or: "The future is all automotive. "In 1963, he opened the first hypermarket. In 50 years, 1,800 others followed, always larger, with a shopping mall and a huge parking lot in front, generally located on the outskirts of a town to attract both urban and rural customers. 47 France has become the country with the most hypermarkets in the world. In just a few decades, supermarkets have captured two-thirds of trade (Héran, 2004).

In the 1980s and 1990s, most French people now believe that it is impossible to do errands other than by car, even though in the Netherlands they are commonly done by bicycle. Even modest shopkeepers are convinced that easy access by car is essential for the success of their business and dream of customers with high purchasing power, who can come from far away and are able to transport large quantities, and therefore necessarily motorized. Any reduction in car traffic or parking spaces is, therefore, experienced as a challenge to their hard work to win over and retain customers.

Studies that look at customer travel patterns in different countries reveal a rather different reality. They have been conducted separately in several European countries - Germany, Austria, Belgium, the Netherlands, etc. - and yet they have produced concordant results, which can also be found in France. The French study of 1,300 customers in city-centre and local shops in 2003 shows that pedestrians and, to a lesser extent, cyclists are much more loyal customers than motorists, because they are limited in their movements and are not constantly tempted to look elsewhere. Although they spend, on average, a third less per visit in each store, cyclists and pedestrians come two and three times more often than motorists, respectively. As a result, bicyclists spend, on average, 12 percent more per week and pedestrian’s 86 percent more than motorists.

The key argument remains for mass distribution: by weighing on prices, it increases, she says, the purchasing power of households. In fact, it also makes them bear the cost of the last few kilometres of transporting products to their homes. Instead of being able to walk or cycle to nearby shops, customers are forced to have a car to go to more distant hypermarkets, where they waste time in the immensity of the facilities or waiting at checkouts.

It is precisely in these peripheral shopping areas, which are very difficult to access by bicycle, that most bicycles are sold in France. Multi-sports superstores and food superstores, almost always located in these roadside areas, alone account for three-quarters of bicycle sales. By their geographic location and their offer, they give an image of the bicycle that is far removed from that of the utility bike. Bicycles designed for mobility (city bikes, electrically assisted bicycles and folding bicycles) account for less than 10% of the market in France.

1.5.8. The new national bicycle policies

In the 1980s and 1990s, there was a striking contrast between France, the United Kingdom, Italy and Spain on the one hand, and the countries of Northern Europe on the other. In some countries, progress was laborious or non-existent, while in others, the ambition was quite different (Huré, 2009).

In France, urban cyclists and cities are gradually organizing themselves to demand a revival of the national bicycle policy, which was abandoned in 1980. The French Federation of Bicycle Users (FUBicy), created at the end of 1979, set itself the objectives of promoting the utilitarian bicycle as a mode of travel in its own right, encouraging the exchange of information and experience between associations and acting as their interpreter to the State.

In spite of the disengagement of the CETUR and the decentralization laws of 1982, some cities continue to request the CETUR and the CETE to carry out bicycle facilities. These government departments then decided to organize a "day of reflection on how to take better account of light two-wheelers in the urban environment", which was held on 14 June 1984 in Paris, and suggested that the cities present should create the Club of Cities Friendly to Two-Wheelers). The CETUR and the CETE were then asked to organize a "day of reflection on how to take better account of light two-wheelers in the urban environment". It was in this context that Hélène Desplats, a city councillor in charge of light two-wheelers in Bordeaux, took the initiative of convening the first national meeting of bicycle cities in that city on 28 October 1988 (Goodwin et al., 1991). This meeting led to the creation, in January 1989, of the "Club des villes cyclables" (Cycling Cities Club). Nine cities, including Bordeaux, Strasbourg, Toulouse, Lorient and Chambéry, immediately joined. The objectives are to encourage the exchange of information and experience between cities, to act as the local authorities' interpreter to the State and to open dialogue with all stakeholders. Some cities are now unashamedly demonstrating their willingness to engage in proactive policies in favour of cyclists.

Starting in the 1990s, these two associations grew rapidly. Their lobbying and two pioneering bicycle consultants prompted the government to wake up. In 1990, after a cycling tour of the most cycling cities in France, consultant Isabelle Lesens drew up a list of winners - the first of its kind - which appeared in June in 50 Million Consumers. The media rediscovered the bicycle on this occasion. In March 1993, Michel Barnier, President of the Savoie General Council, was appointed Minister of the Environment. He was persuaded by consultant and Savoyard Pierre Lortet to hire a bicycle project manager. Isabelle Lesens was chosen, at the end of 1993, for a few months

On July 5, 1994, the Ministers of Equipment and the Environment (Bernard Bosson and Michel Barnier) announced the implementation of a national bicycle policy. They appointed a bicycle correspondent at the CETUR and in each CETE and created a national post of bicycle mission manager - Jean Chaumien - assisted by a monitoring committee bringing together all the players concerned and chaired by the Ponts et Chaussées engineer, Hubert Peigné. A vast project concerns the development of a bicycle network between conurbations, as part of a European plan. Another urgent task is to develop legislative and regulatory texts.

In November 1995, a circular from the Ministry of Public Works encouraged cities to take a serious look at cyclists. On December 30, 1996, the LAURE (law on air and the rational use of energy), in its article 1, states as an essential objective "the reduction of automobile traffic, the development of public transport and the development of economical and less polluting means of travel, in particular the use of bicycles and walking". It makes it mandatory to draw up an urban transport plan (*Plan de déplacements urbains*, PDU) in urban areas with more than 100,000 inhabitants, obliging them to take into account all modes of transport. The decree of September 14, 1998 prohibits motorized two-wheeler bicycle paths, no longer makes them mandatory for cyclists and authorizes the circulation of cyclists in pedestrian areas, "at walking speed". In 1999, the City of Paris and RATP opened bus lanes to bicycles more widely. Finally, the Solidarity and Urban Renewal Act (*Loi relative à la solidarité et au renouvellement urbains*, SRU) of December 13, 2000 reaffirms the objective of reducing car traffic.

During the 1990s, the network of bicycle correspondents built up its expertise, drawing on the experience of France's most advanced cities - including Strasbourg - and renowned foreign cities. In 2000, its work led to a book of Recommendations for cycling facilities. The 1974 SETRA guide, so caricatural, was finally replaced.

In the United Kingdom, after the Thatcher decade, several reports denounced the deadlock in the "all-car" movement and proposed, among other things, to rehabilitate the bicycle (NC Unwin, 1995). In 1992, the British Medical Association, concerned about the rise in obesity, issued a report in which the health benefits of regular bicycle use and its contribution to reducing pollution, noise and congestion were highlighted. (Golbuff et al., 2011) The British Medical Association's report was widely acclaimed for the health benefits of regular bicycle use and for its contribution to reducing pollution, noise and congestion. The report was published in 1992. The Cycling Touring Club (the federation of cycling associations) and Sustrans (a very dynamic foundation, financed mainly by the National Lottery, which is responsible for building the Greenways network and promoting cycling) immediately took up this argument and a few others to call for a national cycling policy. In 1996, the government launched the National Cycling Strategy, a very ambitious cycling development plan with generous targets. Unfortunately, it was poorly funded, poorly managed and, above all, forgot to touch the car (Crow, 1993).

In Italy and Spain, the motorization gap has finally been closed, but the governments' priority is not yet to revive cycling. The car is too recent a conquest to encourage a return to the bicycle.

In the Netherlands, the Ministry of Transport has been supporting city initiatives since the 1970s. In 1990, the first Masterplan Fiets (National Bicycle Plan) set ambitious targets for the development of bicycle use, bicycle-collective transport intermodality, reduced road insecurity and reduced risk of theft. A guide to facilities has been produced (Guit, 1993), followed by a guide to parking, particularly near stations (Laferrere, 2001). A very elaborate tax system, adopted in 1995, makes it possible to reimburse business trips made by bicycle and part of the cost of home-to-work trips by bicycle or the purchase of a bicycle used for this purpose. A rigorous review was carried out in 1998 and a second plan followed.

In Germany, a federal country, initiatives come mainly from local authorities. For its part, the State organizes numerous competitions to stimulate them or encourage exchanges of skills. In 1982, it was decided to make the construction of bicycle paths along national roads mandatory, and many Länder are also developing them along the most frequented secondary roads. In 1997, a new highway code authorized the construction of Fahrradstraße (priority streets for cyclists) and two-way cycling on one-way streets. A tax rebate is decided for users who commute to work by bicycle. Finally, in 2002, following the example of the Netherlands, the federal government launched the Nationaler Radverkehrsplan 2002-2012 (National Bicycle Travel Plan), which aims to better coordinate local bicycle promotion measures, to share experiences through a working group, to harmonize the legal framework, to disseminate results and to identify research needs. The plan is based on the National Bicycle Travel Plan 2002-2012.

In Belgium, a federal country since 1993, the three regions have a large degree of autonomy. Flanders was quickly inspired by Dutch initiatives, while Wallonia, like France, initially considered that the bicycle had no real future (Hubert, 2008). In the Brussels Region, the complexity of the institutions hinders initiatives and the authorities are keen to maintain easy car traffic in the European capital.

1.5.9. “Long live cycling!”

In the countries lagging behind, the desire for national policies has rekindled the hopes of cyclists, some of whom denounce the slow progress made. It is in this context that the Vélorution movement appears in France. Its name is based on a slogan and play on words by public entertainer Aguigui Mouna: “Vive la vélorution” (Long live cycling). It developed in the mid-1990s, following the first "critical masses" that took place in San Francisco in 1992. The principle is to remind motorized users and elected officials of the existence of cyclists by imposing themselves en masse on the road. Critical masses take place every last Friday of the month and are now present in several hundred cities around the world, on all continents. They can bring together thousands of cyclists in a festive yet demanding atmosphere.

In France, most Vélorution collectives do not primarily aim to play the game of consultation with the authorities, as the associations of urban cyclists united in the French Federation of Bicycle Users (FUB) seek to do, at the risk of being recuperated. Their aim is above all to bring to life the utopia of a bicycle society, while denouncing the automobile society. City dwellers are invited to project themselves into a city free of motorized modes and to contribute to it now by using an "autonomous and autogenous" mode of travel that avoids dependence on sophisticated technologies and depleting resources. This is why this movement has a consummate art of the slogan that generally targets the automobile: "Make a gift to future generations, give up your car"; "Turn off your engines, breathe happiness. Turn off your engines, breathe happiness"; "Scrap cars, bicycles instead. "Angry? Pedal! "Zero liter to 100. Clearly, the most exhilarating thing about this movement is its global, youthful, popular, playful and utopian character. In any case, it asks some good questions.

The main author is Ivan Illich (1926-2003), a free and unclassifiable thinker, who analysed the bicycle in his cult book Energy and Equity on Transportation (1973-1975). 1 His formulas, often confusing, can be irritating and sometimes deserve to be nuanced, but are always stimulating. The data provided should be taken with care: many works have since refined the calculations (see box, p. 110).

1.6. The return to grace in the 2000s

In the 2000s, while in Northern Europe the use of bicycles continues to grow, France, the United Kingdom and Spain (and even America and Oceania) are in turn experiencing a revival, with a twenty to thirty-year gap, limited for the moment, however, to city centres and certain publics. It is, in fact, much more difficult to revive a practice that has become confidential, especially in a periphery abandoned to the car. However, a few new arguments can contribute to this.

1.6.1. The "bicycle renaissance" in Northern Europe

After successfully reviving cycling in the 1980s and 1990s, and in the face of encouraging public reaction, many cities and countries in Northern Europe took a bold step and decided to accelerate the movement and redouble their ambitions. Rising environmental concerns and, above all, budgetary difficulties reinforced their convictions. A few edifying examples are worth a detour.

In Berlin (3.4 million inhabitants), thanks to quiet neighbourhoods and a continuous network of bicycle paths on arterial roads, in addition to the generalization of zones 30 (Heins et al., 2010), cycling has almost doubled in 20 years, from 8% to 15%, and the city expects to reach a 20% modal share by 2020. In Münster (270,000 inhabitants, 50,000 students), the share of bicycles in total trips continues to increase. From 29% in 1982, it rose to 38% in 2007, surpassing the car's share of 36% for drivers and passengers combined. It is even 44% in the centre (33% in the outskirts), 50% among schoolchildren and students, and 62% for trips of 2 to 3 km. This is a concrete measure of the bicycle's potential in a flat, fairly compact medium-sized city.

In the Netherlands, the current requirements of urban cyclists no longer relate to traffic calming or the creation of new cycling facilities, which have already been largely achieved, but to reducing the number of stops imposed on cyclists (elimination of traffic lights, creation of gradient crossings, lengthwise profile correction, etc.) and to the ride quality of pavements (improved surfacing, better lighting, regular cleaning, snow and ice treatment, etc.). To evaluate all these aspects and the progress made, the Dutch Urban Cyclists' Association, the Fietsersbond, developed a method - called Fietsbalans - in 2000, which it applied to 150 municipalities, and has since renewed it in about 40. To this end, it uses a sensor-armoured bicycle to cycle through the facilities. In the same vein, a first 7 km "bicycle highway" was built between Breda and Etten-Leur in 1998. The success of this project has led to the construction of similar facilities in other parts of the country. Then, in 2009, the Dutch government released a budget of 25 million euros for the construction of a network of fietssnelwegen (fast bicycle paths) to link the main cities.

In Copenhagen (1.2 million inhabitants), the city aims to increase its modal share from 35% today to 50% in 2020. To encourage commuters to take their bikes to work and reduce the saturation of commuter trains in the conurbation, the city decided in 2010 to build a 300-km network of super bike paths (super bike paths) consisting of 26 mostly radial routes, each 7 to 20 km long. 6 In concrete terms, the aim is to improve the safety and continuity of routes that already exist for the most part: to build or widen certain sections, to build graded passages under major intersections and ensure that cyclists have priority elsewhere, to create a "green wave for bicycles" in dense areas by coordinating traffic lights at rush hour, to improve the surfacing, lighting, markings and signage, and to ensure sustained and regular maintenance. Service stations, equipped with bicycle pumps and patches, will mark out the route. The first super-trail was inaugurated in May 2012.

The purpose of these rapid developments is to improve the network's cyclability and increase the range of bicycle trips. With very few stops, it becomes possible for daily cyclists to ride at an average speed of 20 km/h and cover 10 km in half an hour. More generally, if the average speed of cyclists everywhere is improved by 20% to 25%, the area accessible by bicycle increases by about 50% - because accessibility depends on the square of the speed - which is quite appreciable.

Today, all specialists agree that we are witnessing an unquestionable "bicycle renaissance" in Northern Europe (Golbuff et al., 2011). Can the same be said of the European countries that missed the turning point of the 1970s?

1.6.2. In the United Kingdom: work on behaviours

In this cradle of Puritanism, the natural tendency is first of all to try to convince people to adopt more virtuous behaviours, by encouraging them to use more ecological and healthier modes of transport, which does not prevent them from adapting the roads to these modes of travel and calming traffic. Two programs for schoolchildren and employees have been developed to this end.

Created in 1993 by Sustrans and inspired by a Danish initiative that began in the late 1970s, the Safe routes to school program aims to make trips to school safer and encourage children to walk or bike to school. The aim is not only to support schoolchildren, but also to work with municipalities from the outset to create pedestrian and bicycle facilities and to moderate speeds by establishing 20 mph zones (or 30 mph zones) and home zones (or meeting zones) around schools and in neighbourhoods. Launched in 1999, the government's Cycle to work program is also based on persuasion. The principle is to grant a tax exemption to employers who lend bicycles and safety equipment to their employees to cycle to work, with the possibility of buying the bike later at a very good price. In 2010, 255,000 people benefited from this scheme (Jones et al., 2016).

In England, the Department of Transport's Cycling England mission decided in 2005 to subsidize six pilot cities for three years. Thanks to multiple initiatives, they have managed to increase cycling by an average of 27%. Based on this success, 11 other cities were selected in 2009, including the country's three most cycling cities: Cambridge, York and Bristol. The latter city (430,000 inhabitants) is at the top of the list; it is also home to Sustrans.

Cycling in London has been on the rise since 2001 and has more than doubled in ten years, albeit from a very low base (now about 2% modal share). In 2010, the city council took the measure of the phenomenon and decided to launch a "cycling revolution" aimed at making London "as cyclist-friendly as Copenhagen or Amsterdam," according to the mayor. This "vision" revolves around three main measures. The first is the launch in July 2010 of a self-service bicycle system in the centre, sponsored by Barclays Bank and equipped with 6,000 bicycles, to which 4,300 more will be added by the end of 2013. This service has been a great success. The second measure aims to build twelve radial bike lanes in the inner suburbs (Inner London), pompously called cycle superhighways (superhighways for bikes). Five of them have already been built. However, they are often only cycle lanes with interlocking lanes at crossroads, painted in Barclays blue and located in bus lanes that are not widened or even shared with cars. The third measure consists of creating biking boroughs in the outskirts (Outer London), the details of which are left to the initiative of the local authorities.

These measures make cyclists much more visible, but do not sufficiently ensure their safety, with five deaths reported in November 2013. It is true that the capital's road network is particularly narrow and congested. London cyclists are also quite different from Parisian cyclists. Having been subjected to greater constraints and having to make longer journeys (London is a much more spread-out city than Paris), the survivors are more seasoned, ride faster and wear fluorescent clothing and helmets more often. To broaden this cycling public to other clienteles and to deal with the many criticisms of its facilities, the city council adopted an ambitious investment plan in 2013 aimed at increasing the initial budget fivefold, bringing it to more than 900 million pounds in ten years (Grundy et al., 2008). These safer developments will not happen without taking up space from the car.

In the United Kingdom, generally speaking, urban bicycle facilities are less frequent than in France, but traffic calming is more advanced. The redesign of traffic plans is also well under way, probably because they were implemented earlier than in France, in the 1960s, and the generation of elected officials and technicians who introduced them has not been at the helm in recent years. Cities such as Oxford and London have begun to revise their traffic plans by redesigning their two-way arteries and eliminating many traffic lights, often replacing them with mini-roundabouts (invented by Frank Blackmore, an Englishman at the Transport Research Laboratory, who is a research fellow at the Transport Research Laboratory). The creation of quiet zones is also progressing rapidly, particularly in London (CERTU, 2010).

In all cases, pedagogy and pragmatism are the order of the day and all projects are subject to detailed financial reports. Here again, it seems that calm traffic is the best way to reinforce the return of the bicycle.

1.6.3. In France: the return of bicycles to city centres

Almost all French people can ride bicycles (compared to less than half of Americans). In the country of the Tour de France, learning to ride a bicycle is part of children's basic education and the sense of balance acquired on this occasion is not forgotten. However, according to the ENTD 2007-2008, only 40% of the population still uses a bicycle, either regularly (13%) or occasionally (27%). However, the share of bicycle trips in total local trips (i.e. less than 80 km) has hardly decreased any more, from 4.5% in 1982, to 2.9% in 1994 and 2.7% in 2008. After decades of decline, this near-stability is an event. It is more than confirmed by the results of the latest EMDs, all of which show an upturn in the practice in these agglomerations. This return is part of a change in mobility that breaks with past trends, at least in the major cities where we are seeing a decline in car travel, with a slowdown in the increase in distances travelled and an increase in public transportation and walking (Orfeuil et al., 1989).

In just one generation, urban cyclists have changed a lot. In 1982, the typical cyclist was a rather young man, without a driver's license, from a large family, working or farming, often immigrant, with modest income and little or no motorization, riding in the suburbs or in a provincial town. He used to ride his bicycle to school or work, dreaming of buying a moped and, one day, a car (Papon, 2010). According to the results of the ENTD 2007-2008, these users are still predominantly men (63%), but nowadays they are mainly managers in the public service and the professions, and much less often workers or employees (Ravalet, 2012). In Lyon, according to the 1995 and 2006 EMDs, in only eleven years, the proportion of company and public service managers among cyclists has jumped from 6% to 24%, while that of blue-collar workers has decreased from 23% to 15% (Papon et al., 2010).

Another major change, according to the ENTD, is that bicycle trips are no longer made in the same places: "Compared to 1994, bicycle use has risen sharply for Parisians (from 0.3% to 2.7%), residents of centres in large urban areas (from 2.6% to 3.9%), and to a lesser extent resident of centres in small urban areas (from 2.4% to 3.0%). While it is stable in the suburbs of Paris, its use has declined everywhere else, in the outskirts of provincial cities. The increased use of bicycles for urban travel has been a significant development in the last decade. 16 "The EMDs also note that in all major French cities, bicycle use is rising sharply in the centre, but is rising much less quickly in all of these cities. Since the periphery is more populated than the centre, this means that cycling continues to decline or stagnate in the periphery.

This distortion of the practice between the centre and the periphery is a French particularity. In Germany, according to the 2002 national transportation survey, the modal share of bicycles is 10% in both the centres and the outskirts. 18 This is due to the fact that in France, in contrast to Germany, traffic calming efforts are mainly carried out in the centres, while the urban peripheries and medium-sized towns are often abandoned to the car. In Roanne (70,000 inhabitants), the only medium-sized city to have carried out two EMDs, the modal share of the car has risen from 63% in 2000 to 67% in 2012. Many elected officials and residents still consider that the calmer areas can only concern the centres of large cities and that motorists should not be "bothered" elsewhere.
The average densities are however favourable to cycling. On the outskirts, cycling is the equivalent of walking in the city centre. Although the density is ten times lower there, the cyclist can, in principle, access a space twelve times larger than on foot and therefore have access to as many potential destinations as a pedestrian in the city centre. With access to stations by bicycle rather than on foot, public transportation also becomes more efficient compared to the car. In addition, larger catchment area tends to limit the rise in prices around major railway stations, a perverse effect of rail-oriented urban planning. For this potential to be realized, however, the cyclist must benefit from traffic conditions on the periphery equivalent to those of the pedestrian in the centre, which is far from being the case at present.

In addition, most of the distances travelled by city dwellers can be done by bicycle. For example, in the cities of Strasbourg, Lille and Lyon, two-thirds of trips are less than 3 km. However, 28% of trips of less than 1 km and 60% of trips between 1 km and 3 km are made by car. In the outskirts and medium-sized cities, these small trips are still significant. For home-to-work journeys, 38% of provincial residents work in their commune of residence. This rate is still 26% in the Île-de-France region. In this region, "taking into account the municipalities adjacent to their commune of residence, nearly four out of ten working people work close to home 20 These proportions give a first idea of the potential use of the bicycle.

Faced with this resurgence of the practice, elected officials are beginning to mobilize. The unexpected success of Lyon's self-service bicycle system, Vélo'V, launched in 2005, is part of this trend. Many municipalities are looking to repeat this feat, with varying degrees of success, but they quickly realize that it is not enough to constitute a cycling city policy. They then announce ambitious cycling plans, without yet being able to judge whether they will actually be implemented.

The national bicycle policy has also been expanded in recent years, following the publication in 2004 of a report aimed at "encouraging the development of bicycles in France", and at the instigation of the interministerial task manager for bicycles, Hubert Peigné. Inspired by a Belgian initiative that took shape in 2004, the decree of July 30, 2008 introduced meeting zones (or "zones 20"), made it mandatory to cycle in both directions in zones 30 (Guidez, 2007) (unless the mayor gives a reasoned opinion to the contrary) and laid the foundations for a "street code" by stating that drivers "must at all times behave cautiously and respectfully towards other users of the roads open to traffic" and in particular towards the "most vulnerable users".

The health and sports authorities are finally convinced of the beneficial nature of cycling in everyday life, now integrated into the various health prevention plans. The "national bicycle plan" announced in January 2012 takes a number of measures: the appointment of a new bicycle coordinator, Dominique Lebrun (who succeeds Peigné), and an increase in his budget (which remains very modest), the creation of a new sign authorizing cyclists to turn right at traffic lights if necessary, the obligation to create a bicycle room in any new building, and the setting of a target of a 10% modal share for bicycles by 2020.

Finally, in July 2012, the *Cycling Towns and Territories Club* (Club des villes et territoires cyclables, CVTC) is launching a Club of parliamentarians for the bicycle, based on the English model, which aims to "promote the use of the bicycle as a mode of transport in its own right and in all its components - utility, leisure, tourism, sport - by giving it a special status in legislative texts and projects". After eight months of existence, it already has 96 deputies and senators, representing 10% of Parliament. The results are not yet in, but cycling has never generated so much debate.

1.6.4. The controversial role of bike share systems

Self-service bicycles (bike sharing) have many advantages, starting with their very modest cost of use, which is two to ten times less than a conventional bicycle (this range depends on how the cost of using the bicycle is calculated and the cost of subscribing to the bike sharing system). Users appreciate the ease of borrowing and the possibility of trying out the bike without making a commitment. The first half hour free of charge (excluding subscription) is also popular. The "one way" option - no obligation to take the bike back to the starting point - gives great flexibility of use, allowing users to change modes during the day, in case of bad weather, a hill to climb, fatigue or a chance encounter. The bikes are available at any time of the day and especially at night when public transport is out of service. Finally, many people find that borrowing these public bikes puts an end to the problems associated with owning a bike: purchase, maintenance, parking and the risk of theft. All these advantages explain the success of the largest public bicycle systems, those that reach a critical size in sufficiently large and dense city centres.

Cities, for their part, see it as an effective communication tool to improve the image of cycling. Two years after its inauguration in Lyon, there is no doubt that, thanks to its highly publicized success, "Vélo'V has "relegitimized" the bicycle in the city (Michaud, 2007)". The Cycling Cities Club even considers that the VLS has been "the revealer of the potential for the development of cycling (Ravalet et al., 2007)".

However, in the French cities that have installed the largest systems (Lyon, Montpellier, Paris, Toulouse, Toulouse, Bordeaux, Strasbourg and Lille), where they are likely to have some influence, the rise in cycling has always preceded the arrival of LSVs by several years. This was clearly the case in Lyon long before the launch of Vélo'V in 2005, since between the 1995 and 2006 EMDs, the modal share of bicycles quadrupled in the centre (the municipalities of Lyon and Villeurbanne), whereas since 2006, LSVs have accounted for no more than one-third of the bicycles in circulation in this area. In Lyon, the increase in cycling is clearly due to the fact that, between the 1995 and 2006 EMDs, the modal share of bicycles quadrupled in the centre (the municipalities of Lyon and Villeurbanne). The same is true in Paris, where cycling has been on the rise since at least 1994 (and much more than motorized two-wheelers), 13 years before the inauguration of Vélib' in July 2007 (see box on next page). In the other cities, too, the use of public bicycles has increased by 40% to 150% in the centre, according to the EMDs, well before the arrival of public bicycles (Pro Velo, 2013).

The demonstration can also be done for Barcelona, Montreal, Brussels, Vienna, London or New York, which have launched their system to accompany a bicycle practice already in full revival. In Brussels, for example, counts show that cycling increased 4.5 times between 1999 and 2012, at a fairly steady rate of 10% to 15% per year, while 5,000 VLSs are gradually being deployed throughout the region since 2009 alone.

Who are the users of public bicycles? Three groups can be distinguished. The first is that of users who previously used other modes, i.e. from modal shift. The few surveys found, carried out in Lyon, Barcelona and Lille, show unsurprisingly that they are mostly former pedestrians or public transport users, and few former car users (about 10%). Understandably, cities do not like to announce this type of result. The second group is made up of regular cyclists who have swapped their personal bike for a public bike, taking advantage of the bargain effect of their low cost of use. In Lyon, Barcelona and Lille, the above-mentioned surveys estimate this share at between 4% and 6%. In Paris, where there are more cyclists - prior to the launch of their bike-sharing systems, the modal share of cycling in the first three cities was 1%, while in Paris it was 2% - it is likely that this windfall effect is greater. The final user group is the group of people who would not have travelled if there had been no LSVs, a phenomenon known as induced mobility. These are people who are attracted by the novelty, ease of use or speed of PLVs. In Lyon and Barcelona, this proportion would be between 2% and 3% (it has not been determined in Lille)

Bike-sharing operators and many elected officials say that the success of public bicycles would encourage city dwellers to return to cycling, including conventional bicycles. "It seems that many cyclists, emboldened by the application of Vélo'V, have taken their personal bikes out of the garage," suggests CERTU. While plausible, this argument ignores two phenomena that have already been reported: first, the return of bicycling to the centre of large cities preceded the arrival of the LSVs everywhere, and second, the windfall effect caused by the low cost of LSVs has, on the contrary, encouraged some users to abandon their conventional bicycles. In any case, after a rapid start, the number of riders often declines by 10 to 20 percent after one or two years, mainly because of the system's unreliability. This may lead some to buy their own bicycles, but others to give them up altogether.

The revival of cycling in Paris

Since 1972, users have regularly pressured the municipality to commit to the development of cycling facilities. In 1979, the City took advantage of the railway developments linked to the TGV Atlantique high-speed train, which departs from Montparnasse station, to create a bicycle path along rue Vercingétorix in the 14th arrondissement. In March 1982, on the eve of the municipal elections, following the bicycle accident of Jacques Essel, President of the MDB, Mayor Jacques Chirac decided to urgently build some thirty kilometres of "courtesy lanes", simply delimited by green marks on the roadway, without any redistribution of space between modes. Criticism was rife and these facilities were quickly baptized "corridors of death". The program was halted and the city would take years to digest this failure.

It wasn't until 1994 that new developments appeared: a bicycle path to pass under the Iena Bridge at the request of the Vélo XV association, little-used bicycle paths in one of the first "quiet neighbourhoods" (zone 30) in the 13th arrondissement, a few parking arches and bicycle locks at two crossroads. On Sunday, July 10, 1994, at the initiative of the Minister of the Environment Michel Barnier, the closure of the riverbank lanes to motorized vehicles and their opening to pedestrians and cyclists undoubtedly signaled the renewal of the practice.

The success was unexpected: Parisians were taking over the area in large numbers and with great enthusiasm. With the strength of this experience, in a few years the city extended this system to every Sunday and public holiday (STIF, 2012).

In December 1995, a subway strike - which lasted nearly a month during the Christmas shopping season - led many residents to rediscover the value of bicycles. Elected the previous spring, Jean Tiberi's team consulted the associations and launched a first bicycle plan at the end of January 1996. Under this mandate, 170 km of bicycle facilities, 70 km of bus lanes authorized for cyclists and 31 zones 30 (including the first under Jacques Chirac) were built.

With the arrival of Bertrand Delanoë's team in 2001, this policy was continued and amplified. During the first term of office, 140 km of bicycle facilities were added, 60 km of bus lanes open to cyclists and 36 zones 30. 7.5 km of arteries were redesigned as "civilized spaces". Vélib' was inaugurated in July 2007 and was a huge public and media success: 250,000 annual subscribers in 2013. This effort continued during the second term of office: 215 km of two-way bicycle lanes, improved doorways, experienced red-light signals, a bicycle house, etc.

According to the counts of the city hall, in fifteen years, from 1997 to 2011, the practice observed in the streets of the capital has been multiplied by 2.4 and is tending to accelerate. Global transport surveys (EGT) confirm this increase, with a doubling between 2001 and 2010 throughout the metropolitan area

1.6.5. A problem of cost and financing

What is the cost of a JCDecaux type LSV? The official figure, quoted since 2007, is 2,500 euros per year per bike. Although already very high, it is certainly underestimated. Bicycle regulation is much more expensive than expected. Vandalism and theft are much more important than expected. Users are reluctant to respect a bike they don't keep and which costs them almost nothing. The bikes are too fragile. And the deficient computer system is causing countless disputes (including the wrongly levied deposit, as public reports from the mediator of the City of Paris, overwhelmed by claims, show). So much so that in Paris, all the players (JCDecaux, the City, a renowned engineering firm such as Indiggo-Altermodal, the project manager who set up the VLS in Strasbourg, etc.) unofficially agree that the annual cost of a bicycle would amount to some 4,000 euros, or about 2 euros per trip or 1 euro per km travelled, i.e. a cost per kilometre of the same order of magnitude as for public transportation. (Topham, 2013) The cost of a bicycle is about 2 euros per trip or 1 euro per km travelled, i.e. a cost per kilometre of the same order of magnitude as for public transportation. 33 Given the scale of this cost, many European bicycle cities have decided not to launch their own bike-sharing services, including Ghent, Munich and all cities in the Netherlands.

Who pays for such an expensive system? It is difficult to answer this question precisely because the data is not public. In any case, it's not advertising, contrary to the claims of elected officials who have chosen billboard companies as operators (JCDecaux or Clear Channel, respectively the world's number one and number two street furniture operators). The system is in fact more indirect: local authorities have agreed to reduce the advertising fee for these operators. In other words, taxpayers pay the bulk of the cost of the LSVs (70% to 80%?), followed by cyclists, who pay a much smaller share (10% to 20%?) and finally the billboard operator, who pays only a small share corresponding to the brand image it offers itself (5% to 10%?). And if costs drift, the display company is in a strong position to negotiate new contract amendments because it owns the equipment and the municipality cannot risk seeing its PLV system shut down overnight.

In Barcelona, the 6,000 public bicycles available, used an average of eight to nine times a day, installed by Clear Channel in 2007 without advertising compensation, cost the city council 18 million euros a year, or 3,000 euros per bicycle for a service that is far from perfect: insufficient regulation, deterioration of the equipment (although the system is reserved for Barcelona residents only), etc. In 2011, users were paying a total of only 3 million euros a year, for a unit annual subscription of 30 euros, or 17% of the cost of the service. In London, the service was supposed to cost the taxpayer nothing, but as The Guardian revealed, sponsorship and subscriptions barely cover half of the expenses (Transpole, 2012).

It is not shocking that the community, i.e. the taxpayer, finances a large part of the service, as it does for public transport. What is problematic, however, is that this share is still very high. As a result, several cities have already raised the price of the annual season ticket sharply, such as Lyon (from 15 to 25 euros in May 2012), Barcelona (from 35 to 44 euros in January 2012) and especially London (from 45 to 90 pounds in January 2013). The Barclays bank, which sponsors the London VLS, has just announced in December 2013 that it has decided not to continue its support beyond August 2015. As the analysts tactfully put it, the VLS "have not yet found their business model".

Long-term rental bike systems (VLD), such as those in Bordeaux, Tours, Strasbourg or Lille, are much less expensive. In Bordeaux, for example, the bicycle loan scheme, launched in 2003 when the streetcar was built, is reserved for local residents and students. It is entirely free and limited to one year. But repairs are the responsibility of the borrower. As a result, the cyclist spares his or her bicycle and pays about half of the actual cost of the service.

In general, HDVs are ten times less costly to the community than LSVs. They provide an equal incentive to get back in the saddle and may be of interest to outlying audiences. Although they are used less during the day, they are used over longer distances and more often replace car trips. Lille, which has both systems, found that 27% of HDV cyclists used to make their trips by car, compared with 13% of those using an LSV (Tronchet, 2014). In the city of Lille, which has both systems, 27% of HDV cyclists used to make their trips by car, compared with 13% of those using an LSV. The solution that emerges in the end is to have a limited HSV system and a complementary HDV system.

One more word on the Parisian case. Since 2011, the municipality has been striving to tighten the management of the Vélib'. Subscription offers have been expanded and online procedures have been simplified. Bicycles are more solid and vandalism has decreased a little. The availability of bicycles is better, thanks to major regulatory efforts. As a result, the number of subscriptions has risen, as has the satisfaction rate. But all these efforts come at a price, and the annual cost is unlikely to have changed much. The fact remains that the system is helping to enhance the attractiveness of the capital, as the city council welcomes it on its website: "Vélib' has become an essential experience of a visit to Paris whose motivation is to "live Parisian-style" and discover Paris in a new light. Vélib' undoubtedly enjoys an international reputation and remains the largest self-service bicycle hire system in the world...".

1.6.6. The difficult relaunch of a practice that has become confidential

In most French cities, cyclists have become so rare that other users, technicians and elected officials have ended up ignoring them, without showing any hostility towards them. It was simply a matter of taking note of their virtual disappearance. As time went by, a whole generation ended up not being interested in bicycles at all. The know-how of the technicians was lost. The inhabitants can no longer imagine riding in traffic. Bicycles rust in cellars or at the bottom of garages and end up in the dump.

However, in all cities, there is always a core of diehards who continue to cycle for various reasons: out of nostalgia, for pleasure when the journey is suitable, for economy, to try to stand out. In Paris, Lyon or Marseille in the 1990s, this group did not even represent 1% of trips (certainly five to ten times more if you count the occasional cyclist). However, even at such low levels, bicycle use can sometimes bounce back during fortuitous events: the Paris metro strike in December 1995, the sharp rise in oil prices in 2006, the annual bicycle festival in Nantes in early June, with a superb ride along the Loire River that can bring together more than 20,000 participants...

From then on, demands began to emerge: some daily cyclists decided to call for bicycle facilities, founded an association and demonstrated, citing the exemplary case of other similar cities. The press often relays these demands with benevolence. But relations with other users and the authorities then become conflictual. Isn't this desire to revive the utility bike a regression, a return to the degrading and tiring use of muscle power? Isn't it a frontal and absurd questioning of "automotive progress"? If these apprehensions are overcome, the idea of making room for small group users in an urban environment where space is already highly coveted remains difficult to admit.

In this case, all the protagonists develop unattractive and sometimes aggressive behaviour, which can be broadly described. Feeling permanently threatened, the "residual" cyclists easily rebel against all the other users, denouncing without much nuance the crusher and the unconscious. As Didier Tronchet humorously explains in his delightful Petit Traité de vélosophie: “Existing on a bicycle therefore implies yelling at the car. It's a question of survival. In the natural balance, too many predators threaten the disappearance of a species” (Serraf, 2010). More provocatively, journalist Hugues Serraf is ecstatic: “Because that's one of the major attractions of the bicycle, indeed the mark of its superiority over any other mode of urban transportation: the transformation of each trip into a mini-adventure in which you are the hero. There's a beginning, an end, multiple villains to fight, a lot of twists and turns, speed, adrenaline per liter, in short, the exact opposite of what a trip on the metro will bring you - not to mention a bus ride, the height of boredom in urban mobility” (ONISR, 2008).

Pedestrians, for their part, become hostile to cyclists, harshly denouncing those who ride on sidewalks or run through traffic lights while passing under their noses at crosswalks. In their eyes, cyclists would cause serious accidents and even kill many pedestrians. In 2006, for example, two pedestrians were killed by cyclists, 40 by motorized two-wheelers and 448 by cars or trucks (CERTU, 2010). “The stakes in terms of safety are modest”, CERTU points out in a fact sheet devoted to cohabitation between pedestrians and cyclists, and are even “very low” in pedestrian areas, with “at most the discomfort felt by some users” in zones 30 (Jensen et al., 2010).

This error of appreciation is explained. In the car-friendly city, pedestrians are left with limited spaces where they feel unsafe: few pedestrian areas, thin sidewalks and too-spaced zebra crossings... when these places are not invaded by illegally parked cars. It is understandable that they defend with determination the small area they have left. Cyclists also have the "defect" of being silent.

In a highly motorized urban environment, many pedestrians work only by ear, rely on the absence of engine noise to cross without necessarily looking, and startle when a cyclist appears. In addition, the small size of cyclists makes it difficult for pedestrians to spot them easily among cars. Finally, the behaviour of cyclists who do not respect the highway code - because they are forced to ride in an unsuitable regulatory environment - does not make them very friendly. Because of their greater speed, cyclists can nevertheless hinder or frighten pedestrians and must learn to slow down in their vicinity, if necessary, by discreetly signalling their presence. Training users to respect each other is also necessary: "Welcome careful cyclists", the city of Strasbourg reminds us at the entrance to its vast pedestrian area.

Motorists generally consider cyclists to be a nuisance, clogging up the road and slowing them down, which is obviously debatable, since the size of a car is ten times larger than that of a cyclist and their average speeds are fairly similar in dense areas. They easily have a feeling of superiority towards these users who are considered backward and unable to buy a car. They are in favour of bicycle paths, which have the advantage of clearing the roadway of cyclists, provided, of course, that this is not to the detriment of a line of traffic or parking. This spreads the idea that cyclists have no place on the road.

Elected officials and technicians, both as pedestrians and motorists, tend to share these opinions. Aware that conflicts between pedestrians and cyclists are not so serious, they nevertheless consider, more often than not, that the practice of cycling - likened to motorized two-wheelers - is dangerous and do not wish to encourage this mode of travel. It has been seen that the risk of accidents with bicycles is actually much lower than with motorized two-wheelers. Nevertheless, a seemingly common-sense solution is tending to prevail among those in charge: the mandatory wearing of helmets for cyclists, whose overall balance is actually negative in urban areas.

Many other preconceived ideas are running around about urban cycling. It would be a slow mode, whereas it is faster than all other modes of travel in dense areas (Amoros et al., 2010). The cyclist would be constantly subjected to bad weather, whereas it rains on average in northern France only 6% to 7% of the time, according to Météo-France, and there is suitable protective clothing. The use of a bicycle would necessarily require the existence of showers at the destination, whereas a cyclist does not arrive sweatier than a pedestrian, except to force the pace. The cyclist would be a victim of pollution, even though he or she breathes in barely more pollutants than the motorist. Seniors would be unable to ride a bicycle, which is more relaxing for them than walking. It would be impossible to carry heavy loads on a bicycle; however, it can be done with the help of adapted equipment...

If the elected officials finally agree to commit to achievements in favour of cyclists, the difficulties begin for the technicians. Because they generally have no expertise in cycling facilities, nor any experience of cycling in the city. However, designing bicycle facilities requires as much technical expertise as designing road facilities, as proven by countless failures. An untreated crossroads, a chicane that is too marked, a simple curb that is too high, a sewer grate facing the wrong way... can make a route difficult or even dangerous. To acquire this technical culture, nothing beats visiting more experienced cities to understand first-hand how to deal with all these important details. But this takes time and means.

In addition to all this, the most basic services have almost completely disappeared. Most cyclists have gone out of business and those who resisted have fallen back to recreational bikes or motorized two-wheelers. They are unfamiliar with city bikes and even more so with the accessories that make them easier to use on a daily basis. Cyclists often no longer have the possibility to park their bikes in a safe place. In old homes, deserted bicycle storage areas have long since been converted, and in new homes they have been forgotten (Robinson, 2006).

In short, when the bike has fallen too low, it becomes much more difficult to straighten it, because almost everyone has lost the habit of taking into account the cyclists and has a distorted representation of them, to say the least. Worse still, the bicycle system has become so distorted that it is no longer credible: bicycles that are poorly adapted, embryonic facilities, insufficient services, a degraded image, general discouragement. There is thus a sort of threshold, which seems to be around 4% or 5% modal share, below which everything becomes more complicated. Because France, the United Kingdom and Spain have not been able to turn the situation around in time, everything is now much more complicated for them.

1.6.7. The misguided ecological argument

As everyone knows, the bicycle is the only truly environmentally friendly mechanized mode of transportation. It does not consume any energy, other than the cyclist's metabolic energy, and does not emit any CO_2, except during its manufacture or recycling. It is perfectly silent. It uses one hundred times less materials than a car and materials that are more easily recyclable. Conversely, so-called "clean" motorized vehicles (hybrids, electric vehicles, optimized efficiency, etc.) only have slightly better environmental performance than internal combustion vehicles. They consume a little less energy, pollute less or carry this pollution upstream in the case of electric vehicles. The latter are certainly silent, at least at low speed, but take up just as much space and use more elaborate materials, which are more difficult to extract and recycle (Copenhagenize). Even per person transported, public transport never performs as well as the bicycle, except for space consumption. Finally, like pedestrians, cyclists are in complete contact with their environment through all their senses.

Therefore, the ecological argument perfectly distinguishes the bicycle from other mechanized modes of transportation. However, it does not particularly motivate cyclists, far from it. Like other users, cyclists primarily emphasize the practicality of their mode of travel. Next come pleasure and health, then its low cost, and finally the environment. According to a Danish study, only 1% of Copenhagen's inhabitants use bicycles primarily for environmental reasons (Lesens, 1998). Consultant Isabelle Lesens makes the same observation: “Bicycles are chosen first because they are practical, then because they are pleasant. Ecological criteria are the last motivation” (Inserm, 2008).

In fact, it is mainly the authorities who insist on the ecological argument by talking about the bicycle as a "soft mode". However, it is not more bicycle use that is good for the environment, but less use of the car. If, for example, the new cyclists are former pedestrians - which is the case for most of them - the environmental benefits are obviously zero. This emphasis on the "soft" nature of cycling is not innocent. On the one hand, it is to avoid highlighting the nuisances caused by individual motorized vehicles, so as not to make motorists feel guilty. On the other hand, it is a way of watering down the very interest of the bicycle, since the adjective can be used to describe all vehicles that make an effort to be less aggressive towards the environment. Electric cars and even 4 x 4 hybrids are becoming "soft modes", which is reassuring for motorists.

The ecological argument is therefore not directly justified. Only the reduction of car use is relevant. But such an objective is much more difficult to put forward by elected officials. This is why many elected officials prefer to invest in a self-service bicycle system and a few bicycle facilities rather than take measures to moderate traffic, which are much more effective.

1.6.8. The health argument

On the other hand, the health argument is perfectly correct. Walking and cycling are the only modes of travel that require the muscular strength of their users. We are talking about active or autogenic modes. This characteristic was once considered degrading: until a few years ago, the UN considered that rickshaws - human-powered tricycles for transporting people or goods - very common in Asia, should disappear. The autogenous nature of the bicycle is now considered an essential asset in the fight against sedentary lifestyles and their harmful impacts on health.

Since the 1950s, thousands of scientific articles have gradually demonstrated the considerable benefits of regular physical activity, not only to prevent many diseases, but also to cure them. Existing syntheses on the subject (Andersen et al., 2000) agree that moderate physical activity halves the risk of developing cardiovascular disease, type II diabetes or becoming obese, and significantly reduces the risk of developing hypertension, osteoporosis, colon cancer or breast cancer. Physical activity also ensures harmonious growth in children and adolescents, helps control body weight, reduces anxiety and depression, improves self-confidence and facilitates the treatment of major chronic diseases.

According to the World Health Organization (WHO), moderate physical activity lasts 30 minutes a day or three hours a week, which is typically the average time devoted to daily bicycle use, for example, to get to work 5 km from home in 20 minutes at 15 km/h (or 10 km away with an electrically assisted bicycle). On this basis, a study carried out in Copenhagen followed 30,000 adults, cyclists and non-cyclists, for 14 years. Taking all mortality factors into account, the relative risk ratio of regular cyclists to sedentary people was 0.72, i.e. a 28% lower mortality risk (Irmes, 2013).

These figures are worth quoting when we know that it is estimated that half of the French do not get enough physical exercise (Toussaint, 2000). In 150 years, their average physical activity has dropped from eight hours a day to only half an hour motorization and then by screens (television, computer) has now become a public health problem. However, should we encourage the use of bicycles, which are still more risky than cars? And isn't the pollution inhaled by cyclists likely to cancel out the benefits of physical activity? (Van Wijnen et al., 1995)

The impact of pollution on various street users has been studied extensively over the past twenty years. All surveys show that motorists breathe air that is twice as polluted as that of cyclists and four times as polluted as that of pedestrians, with significant variations according to the pollutants and the arteries they use (Praznoczy, 2012). These results can be explained by the different distance of users from the pollutants that stagnate at ground level. However, cyclists inhale 2.4 times more air than motorists when they are active, which more than cancels out this advantage (Rojas-Rueda et al., 2011). But they quickly learn to move away from the exhaust pipes of buses or trucks that are starting up, to hold their breath for a few seconds at that moment, or to find an alternative, quieter route.

The most recent public health reviews take this into account. A study of the Île-de-France region shows that the benefits of physical activity are twenty times greater than the risks of accidents and pollution, and the gap is widening as the modal share of cycling increases due to the relative decrease in the number of accidents (Papon, 2002). As Olivier Razemon, journalist at Le Monde, summarizes: “Not riding a bicycle is dangerous for your health” (Razemon, 2014). And this result is all the truer in urban areas, where the seriousness of accidents is much less serious for cyclists than in the countryside. This is why, all over Europe and the world, the authorities all end up strongly encouraging the daily practice of bicycling. In France, since 2008, the Ministry of Health has included bicycles in its various prevention plans.

Soon the economic argument

With the economic crisis and the depletion of natural resources, there is no doubt that the economic argument will become more and more consistent. For the moment, the memory of the bicycle as a “poor man’s vehicle” is still too vivid in many minds for the argument to carry. Remember the outraged reactions to the words of Christine Lagarde, French Minister of Economy and Finance, who recommended, in early November 2007, "riding a bicycle" to cushion the rise in fuel prices. Yet bicycles are very economical for users and even more so for local and national authorities.

For users, the comparison of private costs, i.e. directly borne by the user, reveals that the bicycle is well placed among the other modes of travel. However, it all depends on how these costs are calculated: per kilometre or per trip, taking into account or not the value of travel time and therefore the average speed of each mode. €0.13 in 2010, according to researcher Francis Papon, after compiling numerous studies on the subject (Papon, 2002). He distinguishes between occasional or average cyclists and regular cyclists. The damping of the bicycle - including the risk of theft and the anti-theft device - is very high for the former but low for the latter. The opposite is true for other costs, so that the overall costs are equivalent. The budget and time spent on maintenance are well defined, but other often neglected costs are added. Cyclists do not use fuel, but they do need extra food, suitable clothing for inclement weather, and various accessories (turnbuckles, saddlebags, etc.).

For the car, it is not possible to use the "cost price per kilometre" (PRK) calculated by organizations such as automobile clubs, the specialized automobile press or consumer associations, which tend - and have an interest - in inflating the figures to better denounce the so-called hitting of motorists by sellers, repairers or the tax authorities. The solution, explain the economists, is to evaluate this cost by dividing the sum of the annual expenditure of French people on their cars provided by INSEE, by the total distances travelled during the year estimated from national transport surveys. The same applies to public transport. In 2010, this gives 0.25 euros/km for a person travelling by car and €0.12/km for a person using urban and suburban transport, compared with €0.13/km for a cyclist

Per kilometre travelled, the bicycle is therefore more expensive and the car less expensive than we think, the bicycle remaining largely advantageous. However, when the value of travel time is taken into account - i.e., by reasoning in terms of “generalized cost” adding private cost and the value of time - the result can vary: in dense urban areas, when the car is not moving very fast, the bicycle is competitive; on the outskirts, the opposite is true. For every kilometre travelled, the bicycle is just as expensive for the user as public transit. As the price of public transportation varies less and less according to the distance travelled, the bicycle is more competitive over short distances. This observation is even more pronounced when the value of time is taken into account.

However, is it necessary to reason by distance travelled? Not necessarily, since city dwellers are always trying to adapt their lifestyle to the modes of travel they use. Cyclists thus save on their trips by reducing both their number and the distances they travel as much as possible. In practice, a family that starts cycling can often forego the need to buy a second car. Similarly, should we think in terms of generalized cost? Not necessarily either, since the time spent on a bike allows you to get active and avoid hours of fitness related to excessive sedentary lifestyle. Finally, we cannot ignore the public costs and the cost of nuisances (Gerardin, 2013).

In any case, it is nowadays perfectly justified to offer economic incentives for the purchase and use of bicycles, even more so than for cars. France does not offer any such scheme, but there are various types of incentives abroad. 57 Some examples. In the Netherlands, an employee can deduct up to 749 euros every three years from his or her taxable income for the purchase of a bicycle (as is the case in the United Kingdom under the Cycle to work program mentioned at the beginning of this section). Since 1995, the Netherlands has also granted a bicycle kilometre allowance (€0.19/km) for home-to-work trips. This has also been the case in Belgium since 1997 (€0.21/km). Austria reimburses journeys for work-related reasons regardless of the mode of travel: for walking and cycling, the scale is €0.24/km for less than 5km and €0.47/km beyond. France is currently working on the implementation of a kilometric allowance (Frick, 2003).

For local authorities, cycling is even more economical, as cycling facilities are much less expensive than road or rail facilities (see Table 2). Although the various modes of travel do not provide the same services, since cycling is often a substitute for other modes, it is legitimate to compare the cost of different facilities. It thus appears that at the same rate, a cycle path is 200 times cheaper than an urban freeway, 50 times cheaper than a heavy metro and 25 times cheaper than a light rail. A bicycle parking space is 30 to 50 times cheaper than a car parking space. By a rather different reasoning, a study in Switzerland shows that investments in so-called "slow modes" are much more efficient than investments in motorized modes.

In short, the development of the bicycle does not pose an economic problem, it is first of all a problem of political choice. All it takes is not to build a single kilometre of urban expressway to finance an ambitious cycling city policy for years to come. A budget of about 10 euros per year per inhabitant already makes it possible to do a good job; this ratio is 27 euros in Amsterdam (Fietsberaad, 2009).

London, which recently announced a very ambitious development plan for cycling facilities, would like to devote 18 pounds (21 euros) per year per inhabitant to this plan, i.e. 913 million pounds (more than one billion euros) in ten years (Akyelken, 2018).

At a time of budgetary difficulties and reduced public subsidies, local governments are beginning to see the bicycle as a low-cost way to develop alternatives to car use and even to expand public transport, the cost of which has been steadily rising in recent years. (Orfeuil, 2004) The bicycle is a good example of a low-cost alternative to the car, but it is also a good example of a low-cost alternative to public transport, which has become increasingly expensive in recent years.

For the State, Social Security and companies, the bicycle is a blessing. Cost-benefit analyses easily show that the benefits of a national cycling policy far outweigh its costs, mainly due to the reduction in health care costs associated with regular cycling and the reduction in absenteeism in companies due to the punctuality and better health of employees who come by bicycle

At the end of his masterly study for Atout France, Nicolas Mercat, from the Indiggo-Altermodal design office, considers that: "If there is only one point to be highlighted in the bicycle economy, it is without hesitation the health issue. The impacts of regular cycling are now known, very well documented and monetarized in a large European study conducted by the World Health Organization. Joining the European cycling peloton would mean for France to go from 75 km/year/inhabitant to 250 or 300 km [a practice corresponding to that of Germany, Belgium or Sweden]. The expected economic impact would be 15 billion euros per year in savings in public health spending, lost working days and the value of additional years of life, far ahead of all other potential impacts" (Mathon et al., 2012). Enough to make up the Social Security deficit. The investment required to achieve this would be ten to twenty times less.

1.7. Some elements of a bicycle city policy

This section temporarily abandons the chronological plan adopted so far, to explore in greater depth certain aspects too briefly mentioned in the previous pages. The aim is to identify the ingredients that appear to be the most essential in the implementation of a cycling city policy in France. The aim is both to draw inspiration from what countries that are further ahead are doing and to take into account the specific characteristics of France.

1.7.1. From the mesh network to the bicycle system and the peaceful city

In order to develop a cycling city policy, French cities, with the help of the CERTU, the CETE and the CVTC, have gradually refined their doctrine, in three stages, taking the same overall approach as all Northern European cities.

Initially, they realized that it is not enough to create bicycle facilities, but that the network must be sufficiently dense and meshed, with a uniform level of safety. A programming effort is essential, through the development of a master plan for cycle routes specifying the structural axes and priority facilities. This involves identifying and dealing with discontinuities, which can be divided into three categories depending on the scale considered: small, annoying obstacles (a curb that is too high, a dangerous manhole cover, an overly tight baffle plate, a defective surface, etc.); larger obstacles that already deter cycling (an undeveloped crossroads, a cycle lane invaded by illegal parking, an artery with no cycle facilities, a prohibited direction, etc.); finally, urban cuts, such as impassable infrastructures or large, non-crossable rights-of-way, which prohibit any passage from one neighbourhood to another or force the cyclist to take large, very discouraging detours. In France, some cities are not yet dealing with micro-obstacles while others are already tackling larger obstacles. Few cities, such as Strasbourg, have a fairly costly but indispensable policy of systematically dealing with cuts through uneven passages.

Secondly, many cities have understood that it is not enough to simply build bicycle facilities and have sought to develop what several authors and organizations have proposed to call, without consulting each other, a "bicycle system" (Héran, 2002; Horton et al., 2012), just as there is an automobile system (Dupuy, 1999). A bicycle system has three pillars: bicycle facilities and parking facilities at home and at the destination; a series of services to combat bicycle theft and facilitate bicycle rental and repair; and a bicycle promotion policy aimed at improving the image of bicycles, encouraging their use and explaining the solutions implemented. The development of self-service bicycle systems and bicycle stands is clearly part of this approach.

Given the limited (but not negligible) scope of bicycle travel, the bicycle system is in fact a subsystem of the “ecological transport system” (Verkehrsmittel des Umweltverbundes in German), which combines walking, cycling and public transport (Soulas et al., 2012) and which Swiss urban planner Lydia Bonanomi has proposed to call ecomobility (Bonanomi, 1990).

Thirdly, following the example of Northern European cities, a few French cities have recently started to take at their word the CERTU remark made in the French manual on bicycle facilities in 2000: "In cities, the best approach is to give priority to speed moderation wherever possible to allow the integration of bicycles into traffic. "Only such a policy can offer cyclists a peaceful environment that is reassuring enough to encourage a large number of city dwellers to return to cycling. In concrete terms, the aim is to generalize calmed zones (Zone 30, meeting areas and pedestrian areas) on 80% of the road network, even creating “30 bridges” on the sections of arteries where local life dominates so as to link the neighbourhoods in Zone 30 (Wramborg, 2000). Among the cities that have such a project, we can mention a few large conurbations such as Strasbourg, Nantes, Angers, Toulouse, Grenoble or Paris intra muros.

For example, the city of Nantes has decided to extend its central zone 30 from 16 to 75 hectares in 2012 and to create a limited traffic zone of 8 hectares in the hypercentre. This ZTL, the first in France, set up in September 2012, is clearly inspired by the Italian example. It includes a maze of pedestrian alleys and five larger streets, including the 50 Hostages course. Two major north-south and east-west bicycle routes, currently under development, will cross the urban area. Zone 30 will be generalized in all neighbourhoods, including the outskirts, and the bicycle facilities completed on all arteries (Huguenin-Richard, 2010). As we have seen, competition from the streetcar is fierce in Nantes. Students, for example, have become accustomed to taking the streetcar rather than bicycles. But, for the whole population, these calmer areas should encourage people to try bicycles again. Already, bicycle traffic has more than doubled in one year in the ZTL.

1.7.2. Moderate speed to reduce nuisance

Speed is at the heart of most accidents. It is not simply an “aggravating factor”, but a major cause, almost always in combination with other factors. Its importance can be explained by the elementary laws of physics and by human physiological limitations. Three phenomena are combined. First, the kinetic energy of the vehicle - its impact force - increases more than proportionally with speed: the faster a vehicle drives, the more dangerous it is. Secondly, the driver's field of vision decreases with increasing speed: people, vehicles and events that occur on the side are no longer visible. Finally, the stopping distance cumulates the reaction distance then the braking distance which is mainly related to the inertia of the vehicle. Here again, the phenomenon is more than proportional to speed. This is why the risk of an accident increases much more than the increase in speed, both for the vehicle occupants and for other street users - especially cyclists.

Conversely, numerous empirical studies prove that by reducing average speeds by 5% to 10%, the generalization of zones 30 reduces accidents and the number of victims by 10% to 30% (Litman, 1999). Furthermore, with regard to the severity of accidents, other studies show that for pedestrians and cyclists, the fatal risk in a collision with a vehicle is much lower at 30 km/h than at 50: 15% versus 60% of fatalities according to CERTU.

Speed does not only affect road safety, but also other nuisances. Some of them always increase with speed, such as accidents, noise, cut-off effects... Others have a U-shaped evolution curve, first decrease, reach a low point, then increase beyond that, such as pollution, space consumption or congestion.

Often put forward by opponents of Zone 30, the case of pollution deserves some explanation. It is true that today's vehicles pollute more when driving at 20 km/h or 30 km/h than at 50 km/h or 80 km/h (Blaizot et al., 2012). But this is only true if the road network does not change. However, in zones 30, traffic is more fluid: traffic light junctions are no longer necessary; mini roundabouts or simple right-of-way priorities become sufficient. Starts and accelerations, which are the main sources of pollution in cities, are much less frequent. In addition, a calmer city favours modal shift, especially in favour of cyclists, as countless studies already mentioned have shown. Finally, some people claim that by slowing down car traffic, bicycles pollute! On that account, any obstacle to the progression of car traffic also pollutes: pedestrians, crossroads, the city itself?

The risk of bicycle accidents

Recent research has for the first time accurately measured the accident rate of cyclists by using data from the “Rhône Road Traffic Accident Victim Registry” instead of law enforcement data, which greatly under-records cyclists injured in accidents. Since 1996, in this department, all hospital structures, public or private, have been mobilized to record accidents, victims and their type of injuries. The results show that, three times out of four, cyclists are injured alone, by falling or hitting an obstacle and not other users. It is mostly these falls that are poorly identified. Hence the need to offer quality, well-maintained infrastructures, to have a bicycle in good condition and to ride safely.

This research also reveals that it is half as risky to cycle in the Lyon area as in the rest of the department. In this conurbation, compared to the car, the risk of being injured (all gravity levels) while travelling is 2.5 times lower on foot, 7.7 times higher on bicycle and 42.2 times higher on motorized two-wheelers (OCDE, 2007). As with pedestrians, older cyclists are by far the most at risk. This risk on bicycles appears to be much higher than the one previously mentioned for the Strasbourg agglomeration (7.7 instead of 2). This difference can be explained firstly by the previously underestimated falls, but also by Lyon's extensive adaptation to the automobile during the era of the very "autophile" mayor Louis Pradel (1957-1976): the A6 freeway crosses the city in front of Perrache station, most arteries are one-way, speeds are high and cycling facilities are still rare. The phenomenon of safety in numbers is not important: the risk of bicycle accidents is three times higher in France than in the Netherlands and probably higher in Lyon than in Strasbourg.

Research on the types of accidents involving cyclists also shows that the majority of them can be avoided by simple precautions: stay away from heavy trucks, do not shave parked cars to avoid unintentional opening of doors, learn to negotiate left turns and roundabouts, and be clearly visible at night.

1.7.3. Fight against theft with the right tools: anti-theft devices, parking, training

Bike theft is generally considered the second biggest obstacle to cycling after road safety. A very comprehensive study, carried out in the early 2000s, takes stock of the situation (Héran et al., 2003). Its results, which we propose to present here, go against many preconceived ideas and it is unlikely that the situation has changed much since then.

France experiences about 400,000 bicycle thefts per year. In the absence of an accurate recording of these thefts by the police, this is an estimate consistent with the importance of this phenomenon in other European countries where it is better known. Half of the cyclists surveyed have had a bike stolen, a third have had parts or accessories of their bike stolen and a sixth have had parts damaged.

Half of the bicycle thefts take place in private spaces, nearly half of which are in a closed room: few cyclists believe it is necessary to put an antitheft device in a closed collective room and even fewer believe it is necessary to hang their bicycle on a fixed point. In public spaces, 7% of the thefts take place in guarded or watched bike parks. The risk is probably much higher in large cities than in smaller ones, but since cyclists are also more cautious, this hypothesis is difficult to test.

The precautions taken by the victims appear to be very insufficient: 22% of the bicycles are not padlocked at the time of theft, 32% of the bicycles attached are not locked at a fixed point and 95% of the cyclists use a poor-quality padlock. In addition, nearly half of the cyclists do not file a complaint, while filing a complaint was refused in barely 5% of cases. It is true that only 6% of bicycles are found, a quarter of which are recovered by the police. But half of the cyclists have no way of proving that the bike found is theirs (no invoice or frame number to produce).

Contrary to popular belief, bicycle thieves are very rarely organized gangs, as this type of theft is not lucrative enough, except when it involves valuable bicycles, especially at tourist sites or sports competitions where vans have been seen loading several bicycles in one go and then selling them on the Internet. The majority of thieves are in fact unscrupulous users who “borrow” - they say - a bike to use it and then abandon it at its destination. Often, it's teenagers or even pre-teens who steal bikes for fun, and sometimes drug addicts who immediately sell their bikes at a low price to pay for their fix. The police thus explain that a large part of the Vélib' bikes stolen - 9,000 in 2012 - are stolen by idle minors in eastern Paris, during the vacation period: a sort of initiation rite to prove one's courage. The thieves therefore benefit above all from the insufficient precautions taken by some cyclists.

Two lessons can be drawn from this observation. On the one hand, a good antitheft device is very strong deterrent to thieves who are quickly discouraged if it resists them. It is true that no lock can resist an experienced and well-equipped thief for more than ten minutes, but this type of thief is extremely rare. To prevent the theft of moving parts, simple solutions can be implemented: nuts rather than butterflies, wires rather than straps... On the other hand, contrary to a common idea, "ugly" - and often less secure - bikes attract thieves just as much if they are poorly protected. Therefore, using a damaged bike and a poor anti-theft device is a bad calculation.

Most victims are inexperienced cyclists. For example, a cyclist with only three years of experience is fourteen times more likely to have his or her bike stolen than a cyclist with fifteen years of experience. This considerable difference is proof of a very strong underestimation of the risk of theft by novice cyclists. They tend to buy a bicycle without taking the necessary precautions to secure it afterwards. Over the years, persevering cyclists gradually take the precaution of buying a good antitheft device and using it to secure the frame and front wheel to a fixed point under all circumstances.

In case of theft, the frame marking makes it easier to return the bike to its owner, but the impact is marginal since only 6% of bikes are recovered. It is also supposed to discourage theft, but those who "borrow" a bike to use it and then abandon it are insensitive to theft. Nevertheless, some organizations such as the FUB are proposing it. Insurance can compensate a cyclist who is a victim of theft, but various clauses restrict its effectiveness: high deductible, no reimbursement if the theft takes place in a public space, obligation to use a good anti-theft device, only one reimbursement per year... This is why preventive measures are much preferable.

Finally, the most effective measure is to properly inform the cyclist about the precautions to be taken as soon as he buys his bike. Logically, this should be the responsibility of the municipalities' communication services and even more so of bicycle dealers. However, the latter are sometimes afraid of scaring cyclists and missing bicycle sales by telling them about the complementary and indispensable purchase of a good antitheft device. However, when a cyclist's bike is stolen, he doesn't buy it back in 20% of cases. When he buys one, it's a second-hand bike in one out of two cases. And if he buys a new bike, he is satisfied with a product 20% cheaper. Thus, bike theft discourages cycling and pulls the cycle market down by encouraging cyclists to buy second-hand or low-end bikes that are poorly adapted to their needs and unsafe.

A roll bar type parking device on public spaces or closed premises are complements to a quality anti-theft device but cannot replace it (except perhaps in the case of well-secured individual boxes). Devices incorporating an anti-theft device are of no interest because the cyclist needs an anti-theft device to stop in other places in any case. Direct or video surveillance is also no substitute for the use of an anti-theft device. In short, it is not enough to create parking facilities or to set up guard systems, it is just as important to inform cyclists about the risk of theft and about the dual necessity to buy a good anti-theft device and to use it correctly. Otherwise, even the most sophisticated parking equipment is of little use.

1.7.4. Improve the image of the utility bike

In France, the image of the utility bicycle and that of urban cyclists is now in full recovery (Michaud, 2007), but there is still a long way to go. For the working classes, the car is a recent conquest, access to it remains difficult and is even becoming more complicated, with the high cost of a driver's license, the fines that multiply with the speed cameras, the price of training courses to recover license points (Dupuy, 2011). Also, a return to cycling, even partial, is experienced as a regression, a forfeiture, even a humiliation. Moreover, for people living in outlying social housing estates, in housing estates on the outskirts of town, or whose jobs are far away or with staggered working hours, many trips are no longer imaginable by bicycle, even when combined with public transportation.
As always, it is the urban elites who set the trends and build the new standards of consumption. They now criss-cross city centres and chic, quiet neighbourhoods on their bicycles, often on public bicycles, using their smartphones to search for LSVs or available spaces. In a curious twist of history, the "poor man's vehicle" has now become a "trick for boo-boo", a new means of social distinction, just as in the early days of the bicycle. Advertisers and some companies have quickly seized on this trendy image to associate it with their trendy products. This is not necessarily good news, as this image can serve as a repellent to the working classes. But it will eventually fade with the trivialization of these new practices.

The bicycle also benefits in turn from the increasingly unattractive image of the car (Paterson, 2010). Young people are taking their driver's license later and later and are in favour of car sharing. Nobody denies the nuisances of the car any longer. In these times of rising fuel prices, it seems absurd to drive alone in the city in a vehicle weighing more than one ton. The elite prefer to travel by cab, the middle classes by public transport or, if necessary, by rental car.

In short, communication is a fundamental lever in a cycling city policy. However, in France, it is very neglected. It should go without saying that the most prominent councillors are setting an example. Unfortunately, many mayors or presidents of groups of municipalities are still ashamed to show off on a bicycle: "You're not going to make me get on a bicycle, I'm going to be ridiculous! "said the mayor of a large city recently, in front of the dumbfounded press, on the occasion of the inauguration of a new bicycle parking lot near the central station. Some, on the other hand, understood it well: in Bordeaux, the mayor Alain Juppé and the president of the urban community Vincent Feltesse inaugurated major achievements together, by bicycle. Similarly, each city should periodically launch communication campaigns to encourage city dwellers to return to cycling, following the example of Strasbourg. The State itself does not set an example. Its few initiatives in favour of active modes are not the subject of any public information. This leads to a great deal of misunderstanding in the field. On the other hand, the most cycling cities and countries do not hesitate to communicate widely on their city or country cycling policy, making it a strong element of their image (Dekoster et al., 2000).

The regular use of a bicycle implies a new way of life. Therefore, communication can cover a wide range of practical aspects: the precautions to be taken in traffic or to reduce the risk of theft, route finding tools and available services (rentals, repairs, security...), or how to go shopping by bicycle. The training may concern schoolchildren to help them come to school by bike, adults who want to learn to ride a bike or regain a little confidence in traffic, employees to encourage them to come to work by bike, cyclists to help them better argue the problem of bike theft, etc. Institutional communication and training, which are not always well received, deserve to be relayed by private initiatives from associations or employers. It is the multiplicity of initiatives, information channels and targets that ultimately makes the message credible.

1.7.5. Implement an environmentally friendly transportation system

In France, the relationship between public transportation and cycling, which used to be difficult, has greatly improved. Transportation users' associations now defend the complementarity between the two modes, as does the public transportation lobby: The *Public transport union* (Union des transports publics, UTP) and the GART. However, there is a lack of understanding of the potential of the main forms of bicycle-public transport intermodality. Drawing on the practices of the most advanced European countries in this field, five forms emerge.

Bicycle drop-off at stations or peripheral stations and car sharing areas is suitable for regular trips. Its potential is enormous: in the Netherlands, 40% of passengers arrive by bike at station (Hull et al., 2014). It usually requires simple covered hoops, possibly with video surveillance, and more rarely a closed park secured by a badge.

The guarded bike near the central station allows the cyclist to arrive in the city by train, to pick up his bike which is waiting for him at night and on weekends in a closed and guarded garage, to ride his bike during the day, then to drop off his bike before taking the train. This type of solution also has great potential: in the Netherlands, 10% of passengers use a bicycle when they arrive at the station, bicycle station in the immediate vicinity of each major station, providing a variety of services: secure parking, a small repair service, the purchase of small equipment, advice, information, and so on.

The bike rented for one or a few days upon arrival by train in the city is suitable for occasional travel (tourism, business, visits ...). The number of users can be very important. Today, the most elaborate system is the one proposed in the Netherlands by the NS (Dutch railways), under the name OV-Fiets. In 2011, the service was present on 230 sites located mainly in railway stations, with 100,000 subscribers making one million rentals per year. For a particularly modest price - 10 euros per year for the annual subscription, then 3.15 euros per rental day in 2013 - subscribers receive a magnetic card that they simply present at the entrance to have a bike for a maximum of one, two or three days. According to OV-Fiets, half of the users use this system for business purposes. There are plans to increase the number of sites outside train stations.

The combination of self-service bicycles + public transport is suitable for occasional trips in dense areas. Its potential is rather low because bicycles cannot be very numerous due to lack of space in front of stations and stations or are not always available. In Lyon, this concerns 15% of Vélo'V (Tran, 2016) users and the same proportion in Lille.

The bicycle on public transport is an attractive solution because it removes the risk of theft, but the cyclist has to handle his or her bicycle and is not sure whether there is a place in the train or whether this transport is allowed. The use of a folding bicycle reduces these problems, but requires an investment of at least 1,000 euros at the outset, as only high-end products are sufficiently stable, reliable and easy to fold. For the carrier, boarding and disembarking delays trains and bicycles clutter up the trains. As a result, it is hardly possible that more than 5% of passengers use this system. Many cyclists demand this service, but it must be recognized that its potential is limited. In the Dutch trains, although there are many bicycle spaces, they are saturated and passengers complain about the congestion of the corridors by folding bicycles. This is why a good part of the solution lies in the combination of "bicycle + public transport + second bicycle". This is also the conclusion of France's most advanced regions, such as Alsace, which has banned the TER 200 - which runs on the Strasbourg-Mulhouse-Basel line - to bicycles during rush hour and in return subsidizes bicycle parks near the stations served.

These five solutions can be combined and all deserve to be encouraged, but it is best to focus efforts on those with the greatest potential (Pressicaud, 2009).

1.7.6. The electrically assisted bicycle

In this concert of ecological modes, the electrically assisted bicycle (EAB) has a significant role to play. The EAB or "pedal-assist cycle" is a "cycle equipped with an electric auxiliary motor with a maximum continuous rated power of 0.25 kilowatt, whose power is gradually reduced and finally stopped when the vehicle reaches a speed of 25 km/h, or sooner if the cyclist stops pedalling. It is therefore not an "electric bicycle".

This double threshold of 250 watts and 25 km/h is contested both by those who find it too low for cyclists to really face obstacles (distances, hills or wind) and those who find it too high because it pushes cyclists to ride fast at their own risk. This compromise therefore seems acceptable: it allows cyclists to have additional power while riding at moderate speeds, without becoming a motorized two-wheeler subject to the wearing of a helmet and banned from cycling facilities.

In spite of its weight and especially its cost, the EAB can be useful in many situations (see box, opposite) and is therefore experiencing a strong development in the most cycling countries where users are willing to pay large sums of money to buy a good bike. In 2012, it already accounted for 12% of the market in the Netherlands and 10% in Germany (compared with 1.5% in France). Some people imagine that it could account for half of the fleet in 30 years' time.

As with LSV, EAV is often overly popular. Many local authorities, companies or administrations are ready to subsidize their purchase but not that of classic bicycles, which are three times cheaper. Such discrimination can sometimes be justified, especially in hilly cities such as Chambéry or Rouen, where the initiative is very successful. But in other cases, it is a kind of technology bonus: the bicycle would only be worthwhile if it is sophisticated. This denies what is, for many users, a good part of its appeal: its ease of use and repair.

The ten uses of the electric-assisted bicycle

In order to understand the rapid growth of EAB in countries with a high level of cycling, such as the Netherlands or Germany, it is necessary to detail the many needs they can meet:
- start more easily without zigzagging;
- facilitate long-distance travel, especially home-to-work;
- to face more efficiently the wind which is the main random obstacle of the cyclist (a real difficulty in the Netherlands);
- crossing hilly territories (not uncommon in Germany);
- carry heavy loads: several children, an adult, a family's weekly shopping, parcels to be delivered;
- avoid a possible blow of fatigue for people who have exhausting jobs, staggered hours, or certain illnesses;
- Overcoming persistent weakness related to disability or age;
- reassure new cyclists who still lack muscle tone and thus promote the rediscovery of cycling;
- Avoid sweating in order to arrive impeccably at work or at an appointment, especially during the heat wave;
- better equip your bike - and therefore make it heavier - without getting more tired...

All these reasons are not exclusive and often combine.

1.7.7. Reconquering various audiences

A cycling city policy cannot encourage some audiences and neglect others, because it is more difficult for the former to get back on the bike when the latter do not feel concerned and look down on them. All generations and all social categories deserve to be considered. One of the reasons for the success of cycling in Strasbourg is the city's ability to maintain an honourable level of cycling among the population as a whole: among schoolchildren and students, as well as workers, employees and managers (Mercat, 2009). Here are a few insights into the different audiences to be won over. We are now entering the field of "mobility management", which seeks to act primarily on travel demand.

1.7.7.1. Schoolchildren

The school public is a strategic target, since learning to ride a bicycle in an urban environment in childhood is a key factor in the continuation of cycling in adulthood. The school public is a strategic target, since learning to ride a bicycle in an urban environment in childhood is a key factor in the continuation of cycling in adulthood. But parents perceive this practice as particularly dangerous. Therefore, to encourage children to go to elementary school or to certain activities by bicycle and to avoid possible taunting by their peers, support seems necessary. This is the purpose of the "vélobus", which ADEME defines as a "system of public transportation by bicycle, on a determined route, with fixed passage times, accompanied and supervised" by adults. This system assumes a strong involvement of parents who must take turns to accompany their children on a voluntary basis, as it is too expensive to pay people assigned to this task. Many velobuses find it difficult to last or only operate one day a week. A more sustainable solution is to make the routes safe, so that the children can become autonomous.

At the beginning of the 1980s, when the urban community of Lille was abandoning its initial efforts to develop cycling facilities, the neighbouring Belgian city of Kortrijk (70,000 inhabitants) was alarmed at the decline in cycling among schoolchildren. It then decided to conduct a major survey to identify their routes and the difficulties encountered, and then began to gradually address them. This was the beginning of the revival of cycling in the city, which now accounts for 20% of trips.

To encourage safe access to colleges by bicycle, feeder bike facilities and institutional bike parks are essential. This is much less expensive for local councils than chartering school buses. For parents, it frees them from the burden of accompaniment. The Hérault General Council has understood this. In 2000, a new secondary school was set up between Jacou and Teyran, on the north-eastern outskirts of Montpellier, along a bicycle path, so that 80% of the future students would live less than 3 km from the school. The surrounding bicycle network is completed and a covered bicycle park has been created. The various actors - municipalities, parents, elementary school - are involved in the project. As a result, half of the middle school students now go there by bicycle (Héran, 2009). Since this success, about ten other schools have been equipped in the department.

Efforts should not stop at middle school, but continue at high school and then at university. To encourage high school and university students to use bicycles, the Regions can set up bicycle garages but must work with the communes and the general councils on the issue of the drawdown. The potential user potential is very high: in the urban community of Strasbourg, for example, 20% to 40% of high school students come by bike. The same is true when a campus is well connected to the bicycle network and not too far from the city centre.

1.7.7.2. The employees

Employees are just as strategic as schoolchildren, because those who take the car to work tend to use it for other reasons as well: accompanying children to school, shopping, etc. This is why company travel plans (PDEs) are an excellent opportunity to raise employee awareness of bicycle use, alone or in combination with public transportation. The bicycle component of an MP can include many measures: a parking lot, assistance with bicycle purchase, free maintenance service, safety equipment offered, advice...

In Grenoble, France, in 1999, STMicroelectronics had 1,900 employees at a site that was saturated and congested during rush hours, located 3 km from the city centre. At the time, 80% of its employees came by car, each using only 2m² of land for their office in a multi-story building, but 25m² for their car. To save space and build new buildings, it decided to launch a new MP by inviting its employees to come to the site other than by car. In five years, with the help of the city, which is improving access to the site by alternative means of transport, she has succeeded in encouraging 14% more employees to use public transport, 11% to use bicycles and 5% to walk (Grenoble, 2017).

1.7.7.3. The customers

Taking into account weekend trips and return trips home, 21% of trips are related to purchases (Beauvais, 2003). For the past ten years, downtown and convenience stores - especially supermarkets and high-discount stores - have been increasingly popular. The French realize that it is possible to shop on foot or by bicycle at a lower cost, certainly by going a little more often to supermarkets rather than hypermarkets and buying slightly more expensive products, but by significantly reducing their transportation costs. This new trend, however, implies the development of solutions for carrying heavy loads, such as caddy-type solutions for pedestrians, saddlebags or even trailers for cyclists. A trailer can carry up to 50 kg, which is much more than the 35 kg average shopping weight in a hypermarket, as some brands can be used as shopping carts, without any break in load from the shelf to the fridge. In the summer of 2013, Intermarché experimented, in some of its stores in the Southwest, with the loan of "bicycle carts" to some of its cycling customers.

Cyclists and sportsmen and women

In the 1960s and 1970s, two-wheeler manufacturers segmented their customer base by reserving bicycles for leisure and mopeds for the city. Today, this idea is still in the minds of many political and technical decision-makers. Yet the recreational and utilitarian uses of bicycles are linked in many ways. First of all, it is inconceivable to create different networks, for obvious reasons of economy of public funds.

1.7.7.4. Women

In a city congested with traffic, women are the first to give up cycling, while men are more reckless. Thus, in French cities with little cycling, women represent only a third of cyclists. Conversely, in a quiet city, they are much more numerous: in Strasbourg, they represent 48% of cyclists and in Copenhagen they are even a slight majority. But gender-based bicycle use also depends on the social situation. In modest families, women have less access to the only car than men or do not have a driver's license. Helping them to use a bicycle is crucial for easier and cheaper access to employment, the city and a richer social life. The solution is to organize sessions to get back on the saddle or, for those who cannot ride a bike, to offer them an apprenticeship. The few bike schools that exist in France and elsewhere are mainly attended by women from minority groups: North African women in France, Turkish women in Germany, Indo-Pakistani women in the United Kingdom, etc. The bike school run by the Ville à vélo de Montreuil association in Seine-Saint-Denis has already trained more than 1,000 students in ten years, developing a method that has now been perfected and recently won an award. Its head, François Fatoux, notes that the bicycle is a powerful means of integration and integration and points out that it is the municipalities in Germany and the Netherlands that directly offer these places of learning (CVTC, 2012).

Many other audiences also deserve special attention: the elderly, the unemployed, doctors and other paramedical professions, teachers or former prisoners for whom the bicycle offers tremendous freedom of movement.

1.7.8. The role of institutions in cycling city policies

The institutions have great difficulty in understanding the bicycle, all the more so because they are large and bureaucratic. They consider this mode of locomotion as marginal - which it is indeed - to the point, often to the point of totally ignoring it in the name of the general interest or of interests deemed superior - which is not acceptable (disabled people are subject to the same difficulties). Because of their excessive compartmentalisation, these institutions are then unable to address the systemic dimension of a city cycling policy, and are content to deal only with certain aspects of it, each service pursuing its objective without worrying about that of the other services. Thus, those most opposed to urban cycling policies are sometimes... the environmental specialists themselves. A park, a road on the riverbank, or a sensitive area should be reserved exclusively for walkers, even if it means forcing them to come by car, for lack of bicycle access.

Institutions too often stop at the borders of their territory, without seeking to coordinate their actions with their neighbours. Closer to their constituents, municipalities are more attentive to cyclists, but the scale at which they can intervene is not the right one, except for the largest ones. When they exist, intermunicipal bodies generally do not have the power to impose coherent solutions on the communes. In the Île-de-France region, where administrative entanglements are particularly complex, the efforts made are still very disparate, except in Paris. On the other hand, Berlin's "bicycle policy" is "facilitated by [its] very simple administrative structure.

Bureaucracy often leads to a nonsensical and absurd application of procedures to the detriment of the objective pursued and the results, i.e. the users. The too rapid renewal of managers (often every three years), which is supposed to facilitate decompartmentalization, may be beneficial in areas where skills are trivialized, but proves to be catastrophic when expertise is in the process of being built up. The stability of the professionals is then, on the contrary, essential. Cycling, often a minor concern, is also easily the victim of political rivalries. Fortunately, these rivalries sometimes work in favour of cyclists: left and right are attacking initiatives to seduce this public. This is the case in the Bas-Rhin region between the city and urban community of Strasbourg, on the one hand, and the department and region, on the other.

Despite all these dysfunctions, institutions are essential in the implementation of a bicycle city policy. A determined cycling officer, supported by a prominent elected official (if possible, the mayor himself or a deputy in charge of traffic), can implement an ambitious cycling city policy, which deserves a specific budget.

To compensate for their lack of knowledge of the terrain and daily practice, elected officials and technicians have every interest in relying on urban cycling associations and forming partnerships with them. This is a tradition in Northern Europe that is also developing in France. The best French example is undoubtedly that of the *Right to bike association* (Association droit au vélo, ADAV), which brings together Lille's urban cyclists. To make its voice heard by elected officials, it first went up against the authorities for ten years. After the 2001 elections, with the city finally showing a stronger willingness to act, the association proposed a partnership based on the following principle to get

out of the confrontation: the institution would pay a substantial multi-year subsidy against the ADAV's commitment to participate in all consultation meetings on urban cycling facilities or services and to promote the achievements among its members and the population.
To date, there are six three-year partnership agreements, renewable, signed between 2003 and 2013, With Lille city and the Nord prefecture councils, Arras city and the Nord-Pas de Calais Region. The association has been able to gradually hire six employees and has opened six branches in the region's largest cities. It now has 1,800 members. The ADAV takes part in hundreds of meetings every year, gives its opinion on most cycling projects and puts forward numerous proposals. A mutual respect with the technical services and elected officials has gradually been established.

This model of consultation is slowly spreading in France. FUB is becoming more and more closely involved in the work of the ministries and is beginning to develop certain services. However, its resources remain derisory: it still has only four employees, whereas its German counterpart, the ADFC, has seventy. A real question remains: are these associations representative of cyclists? Clearly not. Their members are mostly everyday cyclists who, being familiar with the pitfalls of traffic, tend to underestimate the obstacles faced by novice cyclists. Nor do they cover all social groups: workers and shopkeepers in particular are few in number. The partners are aware of this and try to take it into account in their diagnoses and solutions.

1.8. Prospective, the utility and intermodal bicycle by 2050

As its return is for the moment limited to the centres of large cities, the bicycle does not seem credible, in France, for daily journeys, neither today nor tomorrow. In suburban areas, where half of the French population lives, the bicycle continues to decline. With rare exceptions, medium-sized cities are largely dominated by the car. In the rural world, it is difficult to imagine any success for the utilitarian bicycle, despite the increase in leisure or sports activities by bicycle. As for the distances travelled by bicycle, they seem so modest that the environmental interest of shifting to this mode seems negligible.

Also, in French work on urban mobility forecasting, the bicycle is never considered as a mode with a real future. In 1993, in a description of mobility in Northern European countries, the treatment of active modes is not mentioned as a distinctive element (Biber, 1993). 2 In 2000, in the work of an expert group on urban mobility, cycling is only marginally mentioned (Lamblin et al., 2011). In the work of the Strategic analysis center, cycling is considered as one of the modes of transport that can be used as a feeder mode for public transport, but only for short distances

However, in the most recent urban travel plans, French cities imagine a modal share of cycling two to four times greater than today, in just ten to twenty years. They realize that it will be impossible to reduce the modal share of cars by 10 to 20 points by relying solely on the increase in public transportation trips, whose modal share would then have to be doubled at an exorbitant cost. "CERTU believes that a proactive modal shift policy must therefore focus on all the alternative modes to the solo car [sometimes called "solo car use"] (walking and cycling over short distances, electrically assisted bicycles, public transport, carpooling, etc.) and on their complementarity so that each of them can be used in its area of relevance. "

So, what role could ecomobility, and more specifically cycling, play in urban mobility in French and Japanese cities between now and 2050? To try to get an idea, simply extending current trends is meaningless, because everything suggests that we are on the threshold of major changes, environmentally, economically and socially. It is the role of perspective to first identify these changes, then to explore how they should profoundly alter our ways of getting around, and then to estimate the place of the bicycle in this transformed context.

1.8.1. Environmental impasses and economic disruptions

Global analyses of human pressures on non-renewable natural resources in terms of the ecological footprint show that the most economically developed countries already consume far more resources than the planet can support (Maillefert, 2018). The global economic crisis has led to a growing demand for natural resources, and the need to reduce the environmental impact of human activities on the planet's resources. Transport is no exception to this reality, but the foresight exercises cited above take little account of it. Will the global car fleet, which today stands at almost one billion vehicles, really be able to more than double by 2050, as the International Energy Agency (IEA) predicts, or even almost triple, as the OECD imagines?

So far, only the crisis of oil resources has really manifested itself (with the controversy over the famous peak oil). And everyone is now convinced that a trend increase in fuel prices is inevitable, with significant short-term variations. As a result, everything is being done to save the automotive system. But the technological challenges to be met are formidable. Hybrid cars, with their dual engines, require greater use of materials and bring only fairly small environmental gains. The electric car is still twice as expensive and four times less autonomous than the internal combustion engine (Pelissier et al., 2013). In addition, if we want to avoid increasing greenhouse gas emissions, electricity must be generated from nuclear power with battery recharging during low consumption periods, i.e. at night, to avoid having to use auxiliary thermal power plants during peak periods (Crozet et al., 2008). This will lead to tensions over the supply of uranium, not to mention the technical and economic problems of dismantling end-of-life power plants and reprocessing waste, which will necessarily have an impact on the cost of electricity.

But the essential problem may not be there. In the next forty years, the resources of many metals will be depleted and their prices will soar. Apart from iron, aluminium and silicon, which are very abundant, non-ferrous metals such as copper, nickel and zinc will soon reach their peak production levels. Many metals that are highly sought-after by advanced technologies, such as lithium, cobalt, silver, platinum, cadmium and rare earths, are already becoming scarce, even though they are difficult to recycle (Bihouix et al., 2010). This major issue is not addressed by any of the French prospective work on mobility (Lopez-Ruiz et al., 2011). Only the recent report on the future of the automobile admits, without any further precision, that “the automobile wastes raw materials (between 600 kg and 2,000 kg per vehicle)” (Paul-Dubois-Taine, 2010), most often to transport only one person in a vehicle ten to twenty times heavier. The ratio between the maximum laden weight and the empty weight of a car is at best 2.5, when it exceeds 7 for a bicycle.

Under these conditions, we will inevitably have to get out of the automobile system and move to ecomobility, for both urban and inter-city travel. Only the pace of this change remains a matter for debate. More broadly, energy and resource savings will become the main alternative in all sectors, offering industrial companies very different perspectives: the long-term objective can no longer be the production and sale to individual consumers of goods with programmed obsolescence, but the development of less sophisticated and fewer, more durable and repairable goods, sold to groups of users or offered for rent (economy of functionality). Quantitative accumulation of goods should be followed by better quality goods and services, better adapted to each individual.

Finally, the environmental context is expected to get tougher. The well-known threats linked to global warming are accumulating, and even the World Bank is alarmed (World Bank, 2014). But the most worrisome concerns the systemic interactions between global warming, the increase in pollution and the degradation of biodiversity, three problems that are still too often studied separately whereas they appear to be increasingly linked.

Contrary to what many still imagine, growth cannot continue indefinitely, for at least three reasons. First, as we have seen, energy and metal resources will become increasingly scarce and expensive (Jancovici, 2012). Second, our material needs are not infinite. The rate of household equipment in durable goods always ends up being close to 100%, and it is hard to see which of these numerous goods could take over, even if there will surely be some that are unknown at this time. Finally, an economy increasingly based on services cannot achieve the productivity gains that can be achieved in industry to the same extent as those that can be achieved in industry. In this context, the hypothesis of annual French GDP growth of 2 percent, which several authors of the aforementioned prospective work adopt, is unrealistic. We can now expect a period of lasting stagnation, with episodes of recession (Hienberg, 2011).

As a result, the public authorities, and in particular local and regional authorities, will experience even more serious budgetary difficulties than they do today. They will have to abandon the most expensive capital projects and find new revenues. The creation of major roads will seem out of place and will be abandoned. Heavy public transport projects will be scaled down in favour of low-cost streetcars, buses with a high level of service and rationalization of bus lines, a trend that has already begun. On the contrary, bicycle networks, which are much less costly, will be favoured and coexistence between modes will be promoted as much as possible. School transportation will be limited and access to middle and high schools by bicycle will be encouraged. On the revenue side, city tolls are expected to increase and parking and public transport fares will continue to rise.

Companies will be increasingly called upon to help their employees get to their workplaces at better controlled costs. The company travel plans (PDE) that already encourage them to do so will become more and more directive. Households, for their part, will experience a decline in purchasing power that will force them to reinvent their mobility: by giving up multi-motorization or car ownership, sharing their car, exploring other modes of travel. They should also seek to limit the number and scope of their motorized trips, by simplifying their activity programs, sometimes preferring telecommuting and e-commerce, choosing closer destinations or living in denser or better-served areas. These trends are already working on the company and are expected to increase. Dramatic as it is, the case of Greece is full of lessons. With the crisis, mobility practices have been turned upside down: car use is declining and bicycle use is exploding (Tagaris, 2012). Some see it less as a constraint than as an opportunity to change travel habits.

The seriousness of environmental and resource depletion problems, the impasses into which short-sighted solutions lead us, and the persistent economic crisis will force us to replace our compartmentalized approach to problems with a much more systemic approach, developing integrated solutions that allow us to deal with several problems simultaneously without causing major collateral damage. Thus, automotive-related nuisances will no longer be studied separately by patent specialists, neglecting the many perverse effects of sector-based solutions. The electric car, in particular, will no longer appear as a universal solution, because, although it strongly reduces local pollution and noise at low speeds, it does not eliminate other nuisances and increases the use of rare and expensive materials.

The role of technology will be profoundly rethought. They will be mobilized to design solutions that are simple, robust, efficient, very economical in materials and energy, repairable, recyclable and without harmful indirect impacts, by involving users at every stage of the product life cycle. Despite a few imperfections, today's bicycle already resembles such a product.

1.8.2. New social aspirations

In times of crisis, sensitivity to price changes increases and equity issues resurface. When the cake to be shared no longer grows or shrinks, the majority of citizens no longer tolerate a minority taking huge shares at the expense of the many. Subjects that have been hitherto unimportant or ignored will then be the subject of lively debate.

As soon as the car begins to be used significantly less - some people are already talking about peak car (Bouleau et al., 2013) - those who have made the deliberate choice or are forced to get rid of it will no longer accept, for example, that it monopolizes public or private space by parking there for free. Employees who never come by car will challenge the provision of free parking spaces at the workplace by employers for those who come by car, and could ask for compensation (a space costs more than 1,000 euros per year in the centre of a large city). Pedestrians and cyclists will demand a more equitable sharing of public spaces. They will demand that cars and motorized two-wheelers park in garages or properties rather than on the street.

Similarly, it will no longer be permissible for road pollution by particulate matter and nitrogen oxides to cause so many illnesses and deaths (APHEIS, 2004). The authorities will be led to ask motorists to bear the cost better, depending on the type of vehicle and fuel used (increase in taxes on diesel, reintroduction of the vignette, etc.). It should be remembered, in fact, that while the taxes levied on motorists cover the cost of infrastructure and its maintenance, this is not the case for the nuisances they cause, especially in urban areas where the populations affected are numerous. Motorists are not the "cash cow of the taxman," as the automobile lobby claims, quite the contrary The hierarchy of travel modes will also be profoundly reviewed. The street code will be more rigorously enforced. The "city 30" will gradually become the rule throughout Europe, with speeds in the city being reduced to 30 km/h except on major highways where traffic dominates. Cyclists will have priority at intersections as much as possible. Buses will use emergency lanes on quiet freeways, limited to 70 or 80 km/h (solution already implemented in Grenoble).

More generally, the current values of the consumer society are expected to change profoundly. Several changes could combine to make this change likely. Instead of GDP, which is increasingly contested, new indicators of wealth that modify the objectives of public policy will eventually become the norm, and the single reference to the rate of growth will disappear (Stiglitz et al., 2009). This change of thermometer will not be insignificant and will transform our outlook: the objective will no longer be the incessant accumulation of goods but the improvement of the quality of life and social ties. All the techniques aimed at encouraging consumption - advertising, marketing, lobbying - will also be better and better supervised, because it will seem incoherent that they continue to encourage the waste of resources. The "creative" will surely be able to adapt to this by surfing on these new values. And, above all, the rise in economic and environmental difficulties will generate great effervescence in society - and not just desolation - with a multiplication of initiatives, some of which will end up becoming new standards of behaviour that firms will seek to exploit.

In the transport field, taking into account these foreseeable disruptions in the socioeconomic context, it is likely that by 2050 the current sophisticated automobile will have become beyond the reach of the stagnating or declining incomes of a significant proportion of the population. Cars will be less equipped, less powerful, more durable and more easily repairable, reserved mainly for collective or shared use, for transporting heavy or bulky loads, for emergency services or for the motorically handicapped. There is no doubt that manufacturers will be able to adapt their range to these new requirements, as shown by the unexpected success of Dacia's low-cost vehicles, which by 2013 will already account for 41% of vehicles sold by the Renault group and a third of its profits (Durand et al., 2018).

All this will lead to a real paradigm shift in the ways of producing, consuming and moving. Such a perspective may appear to current generations, obsessed by the growth and accelerated renewal of material goods, as an unbearable constraint and regression. On the contrary, it could appear to future generations as an opportunity to invent new economic and social relationships.

1.8.3. The bicycle as a major ingredient in the future transportation cocktail

In this profoundly changed environmental, economic and social context, the advantages of the bicycle will become obvious. A mode that emits very little pollution, consumes 50 times less energy (Lowe, 1989) times less and is 80 times more material-efficient than the car can no longer be neglected. Therefore, the question is not whether the utility bike has a future, since it should logically regain a place of choice, if not dominance. This is why there is strong public support for current cycling policies, even though the facilities are still often little used

However, a delicate question remains: can the bicycle represent a substantial share of local trips (i.e. less than 80 km), depending on the reasons for travel and the territories crossed? The average daily distances currently travelled have been steadily increasing and seem far removed from cyclists' abilities. However, this trend has slowed down considerably and is likely to level off and then decline in the future as the cost of travel increases. A detailed examination of distances also gives rise to some hope: apart from commuting to work in peri-urban areas in large urban areas, a significant proportion of these trips can still be made by bicycle, since the average distance in each case ranges from 5 to 15 km. (Pappalardo et al., 2010) The average distance travelled by bicycle is between 5 and 15 km.

In dense urban areas, the bicycle will sometimes reduce the modal share of walking, as already observed in some cities such as Münster or Ferrara, but it will also contribute to the pacification of the city to the benefit of the pedestrian. Above all, it will desaturate public transport, making it more efficient over longer distances, i.e., on the outskirts, where it will remain indispensable. Lastly, it will help to further reduce the modal share of the car. The issue of parking in buildings will be addressed, either through the development of bicycle parking spaces, or by a common space for several buildings installed in a former store, or by collective boxes installed on former car parking spaces, all solutions already tested today. In total, it is reasonable to expect that bicycles will provide 20% to 40% of trips in the centres and near the outskirts, probably a little less in cities with excellent public transportation systems. This means that the modal share of cycling will usually be higher than that of public transportation.

In less densely populated areas, the bicycle will increasingly appear as a partial substitute for the automobile, complementing and reinforcing public transport. This is where its potential should be most evident, given the modal shares observed in the most cyclist countries, which are much higher than those observed and imagined in France: in the order of 20% to 40%, instead of the expected few percent.

On the outskirts and in the rural world, on the other hand, the bicycle seems, at first glance, to have no future. The use of the car is outrageously dominant in these sparsely populated areas, where it provides the bulk of trips, including the shortest ones. Some analyses show, however, that short trips - which can be made on foot or by bicycle - are still numerous.

In London, a recent study by the public agency Transport for London estimated that 25% of current journeys in Greater London "could reasonably be made usually by bicycle", compared to a modal share of only 2% today This potential would be of the same order of magnitude in the centre (Inner London) as in the suburbs (Outer London). The shift to cycling would come from 63% of cars, 26% of buses, 7% of trains and the metro and 5% of other modes (the study does not consider that it could be pedestrians).

Using the results of the Lille 2006 EMD, the CETE Nord Picardie (Mathon et al., 2012) shows by a completely different method that, in the metropolis, 49% of all trips could be made by bicycle, saving 155,000 tons of CO_2 per year. This 49% total does not include trips of less than 1 km deemed feasible on foot, trips of more than 5 km deemed not feasible by bicycle, and trips of 1 to 5 km that could be made more quickly by public transit than by bicycle. The potential for bicycle use, assessed here without modifying urban planning, therefore appears considerable in an urban community of more than one million inhabitants, which nevertheless constitutes a fairly extensive conurbation comprising eighty-five communes and where the share of peri-urban travel is in the majority. It should be noted that, of the trips that could potentially be made by bicycle, 70% are currently made by car, 15% by public transit and 15% on foot.

The Brès et Mariolle agency, for its part, analysed in detail the case of the "carré picard", a square of 50 km side located between Saint-Quentin, Soissons, Compiègne and Laon, which can be described as diffuse suburban but still counting 245 000 inhabitants on 2 500 km2, or nearly 100 inhabitants/km2. The study indicates that 30% of the working population works in their hamlet, village or small town and 85% of jobs are reached within 10 km. The average distance from a railway station is 5 km and from daily services is 12 km. Some of these distances can be covered by bicycle.

As impressive as they are, it is doubtful that such potential can really be expressed, given the current state of the bicycle networks in the periphery. Indeed, the current bicycle system is only at the stage of the automobile system of the 1930s, before the advent of the network of major highways that now criss-crosses the territory and the fast, reliable and comfortable cars capable of covering it.

1.8.4. The implementation of a high-performance bicycle system

In suburban areas, in order to make it possible to cycle over longer distances - of the order of 8 to 15 km or more - or to provide efficient feeder services on more direct, intermittent public transit lines, the bicycle system will have to undergo a real revolution, already underway in the most advanced countries, with faster facilities, more efficient bicycles and services that are up to the task.

Future developments will be organized around a main network of more "rolling", better maintained and better lit bicycle lanes. Already the names are jostling: "super cycle paths" in Denmark, "freeways" or "expressways" for cyclists in the Netherlands, "RER cycle RER" in Brussels, "REV" (bicycle express network) in France... These developments will be easier to integrate into the landscape than major road infrastructures. They will accommodate much more efficient bicycles, as we will see, and cyclists who are more accustomed to cycling (by regularly starting to pedal, a novice cyclist quickly increases his or her muscle tone). All in all, a high-performance bicycle system will allow cyclists to move faster or further for the same amount of muscle energy expended, with greater comfort and safety.

As with the current network of expressways, the network of superbike paths will play a major structuring role, linking the main traffic generators and attracting urban planning operations, but without the nuisances linked to the massive flow of cars, nor the excessive zoning of the territory. On the contrary, in a peaceful environment, it will generate a multitude of eco-neighbourhoods, small shopping centres, small business parks and local services. Larger-scale urban planning operations will remain possible around train stations and public transportation nodes.

Some relocations will facilitate this change. As it has already begun, mass retailing will redeploy its establishments by increasing the number of convenience stores (maxi-discount stores, mini-markets and supermarkets) to the detriment of hypermarkets and large shopping centres. The various public services will be both grouped together and decentralized, with a single office providing postal, social security and job search services. Residential mobility of households will be facilitated and employers will help their employees find housing closer to their place of work.

In other words, combined with more direct public transportation, simplified and more frequent trips, the bicycle will make it possible to maintain satisfactory urban mobility in the centre and on the outskirts, including in hilly areas, thanks to electrically assisted bicycles. Only the steepest areas will be less accessible. But it is conceivable that they will benefit from specific aids to overcome this handicap. The decline in car use will not signal the end of easy mobility - with a return to slow pedestrian or tormented bus routes - but only the end of mobility that is costly for public finances, social security, household budgets and the environment.

Finally, a word on the future place of motorized two-wheelers. Some see a great future for them, given the trend increase in their modal share in Paris, Marseille, Barcelona and Rome. However, these cities are rather exceptional. On the contrary, the underlying trend over the last forty years has been a decline in this modal share. Several elements should reinforce the second trend or at least limit the first. The fight against pollution and noise should finally lead to the application of a ban on unbridled or inflated engines, thereby reducing their performance. Similarly, the continued fight against road insecurity will lead to common sense measures such as raising the age limit from 14 to 16 years for using a two-wheeler under 50 cm3 (as in Germany), banning the use of large engines off-road (as in Japan) and better information on the enormous risks involved.

In addition to the increasing cost of thermally-powered vehicles, such developments could change the positive image of motorized two-wheelers among young people and cool down many potential adult users.

Aerial bike paths, robotized parking, bike-skates...: the inventors' junk shop.

There is no shortage of so-called revolutionary inventions in the world of transportation, especially bicycles. Urban transportation has always fascinated inventors of all kinds. Thanks to their discoveries, there's no need to get tired, face traffic, bad weather or theft! However, very few projects succeed in making a name for themselves. New equipment or new infrastructure must be very safe, reliable, practical and above all reasonably priced, both for the user and for the community. A difficult equation to solve.

Through their interpersonal skills or their power of seduction, inventors sometimes succeed in convincing an investor - often the local community they come from - to make a prototype or sell a few examples of bicycles made of recycled cardboard or that can be driven by thought (Estival et al., 2017). But the laws of physics, physiological limits and economic constraints quickly bring everyone back to the harsh reality. Here are three examples that have recently made headlines.

Aerial bike path projects are always a hit: who doesn't dream of riding in the clouds, above the swarming, noisy and polluting cars? All that remains is to deal with the necessarily complex integration and access and to settle the astronomical bill: about 50 million euros per kilometre for the latest project to date, the "SkyCycle", a vast network of "cycling platforms" that its designers would like to install above London's railroad tracks.

Robotic bicycle parking is also one of those "revolutionary" inventions that excite media eager for futuristic innovations. Such a system, called ECO Cycle and created by the Giken company, has been in operation since 2008 in front of some of Japan's major railway stations. Users pay only 1,800 yen (about 13 euros) per month, a very small sum compared to the amortization and maintenance costs borne by the community.

The Pibal, a "skateboard bike" designed by Philippe Stark, built for the city of Bordeaux and put into service at the beginning of 2014, does not bring any new features: any bike can already be used as a skateboard. On the other hand, it is expensive to manufacture because, to avoid a lack of rigidity, its structure is reinforced and, to avoid the resulting heaviness, the frame is made of aluminium.

1.8.5. Adapting cities to ecomobility

In a way, just as the bicycle prepared minds and industry for the arrival of the automobile at the end of the 19th century, the automobile should in turn prepare the ground fairly well for ecomobility.

As car use declines, the enormous amount of space it requires will become available for many other uses, including more space-efficient modes of travel. On major roads, some lanes will be used for streetcars, high-service buses or bicycle facilities. Streets that are less congested by traffic and parking will have their sidewalks widened and local life will take on a new lease of life. The vast parking areas surrounding shopping centres and office buildings will be used as a land reserve for real estate operations aimed at densifying cities and mixing urban functions. Underground parking lots, on the other hand, will be difficult to reconvert and many will become wasteland (as is already the case for some of them).

The first level of a few will be used as bicycle parks (as in Strasbourg) or as a distribution centre for scooters (as for the company La Petite Reine in Paris). In the housing units, the garage will be reconverted into a bicycle room, a workshop, a living room or a studio for rent.

Some manufacturers, distributors and garages, hitherto exclusively dedicated to cars and motorized two-wheelers, will turn to public transportation and bicycles by contributing their technological and organizational know-how. For example, advances in automotive batteries are already being used in electrically assisted bicycles, with much greater success.

Even in terms of values, the car should eventually encourage the adoption of bicycles, since many motorists share with cyclists the attraction of individual transportation and the great autonomy it provides. The bicycle will thus provide access to "car-free motoring" This is an advantage that neither public transportation nor carpooling has.

Generally speaking, the cost of adapting cities to ecomobile modes should be bearable for local authorities, since they will have to give up heavy road projects in favour of lighter public transport projects or adapt existing facilities. Denser urbanization that mixes urban functions will be a useful complement, but not decisive, given the great inertia of the built environment. Employers, on the other hand, will have to help their employees organize their commuting to and from work or even to find housing closer to their workplace (Héran, 2013).

To assess the contribution of cycling to nuisance reduction, the only correct way to proceed is to compare a modal split where cycling is almost absent, walking and public transport are poorly developed and the car is dominant, with another split where cycling would become a major mode, walking and especially public transport would be more developed and the car much less used. A recent study commissioned by the European Cyclists' Federation attempted to assess the contribution to greenhouse gas reduction of cycling in Europe at the same level as in Denmark, taking into account the life-cycle emissions of the various modes of transport, including the electrically assisted bicycle, which would provide half of the home-to-work journeys. The savings would be "63 to 142 million tons of CO_2 per year, or 12% to 26% of the reduction target for the transportation sector" set by the Kyoto Protocol for 2050: a significant result (European Union, 2010).

1.8.6. Back to modernity

In France and in countries with few cyclists, cycle world of tomorrow will be very different from today. As can already be observed in the most advanced countries, the supply of bicycles and accessories will be much more varied, far removed from the current low-end bicycles or gadgets that clutter the French market.

The most spectacular evolutions will undoubtedly concern the transport of people and the carrying of heavy loads, with the trivialization of two- and three-wheelers, cargo-cycles capable of carrying up to 180 kg of goods (various packages, fresh products in refrigerated containers, etc.), cyclo-taxis and other rickshaws carrying one or two adults or up to eight children, tandems, third wheels, one or two-wheeled trailers, towed platforms for moving bulky objects, and all kinds of systems adapted to the transport of particular objects, from strollers to double basses. Bicycle transportation for errands or children will become commonplace. Disabled people will also benefit from many innovations: push bikes or wheelchair carriers, for example.

Already meeting with some success, the folding bicycle should also spread. For two main reasons. On the one hand, it is a very efficient complement to public transportation, especially for occasional trips. For regular trips, the "bicycle + public transportation + second bicycle" solution will always remain more efficient and comfortable, because the folding bicycle is less stable, less safe and less pleasant than a conventional bicycle. On the other hand, it is an acceptable alternative, in case of parking difficulties or high risk of theft.

For all types of bicycles, electric pedal assistance can often be a valuable complement. However, it will probably not equip the majority of bicycles, as batteries are still quite expensive and most trips do not require it. Moreover, the technical complication will put off the most technophobic people, an important attraction of the bicycle being its simplicity.

Thanks to their amazing performance, recumbent bikes and mopeds could be a major breakthrough for fairly long trips - 10 to 20 km or more - of the home-to-work type. There are already several thousand enthusiasts of these machines in Northern Europe and a few hundred in France. On a recumbent bike, the cyclist pedals in a horizontal position, which allows him or her to sit comfortably in a seat and not perched on a saddle, to support his or her back to push more efficiently on the pedals, while offering half as much grip to the wind. As for the Velomobile, it is a streamlined tricycle, a kind of glider without wings, very aerodynamic and therefore even more efficient. The cyclist is also in a prone position, and is sheltered from the weather, which allows him to ride three times faster than a traditional bicycle using the same energy. With its motorized racing looks, it is a vehicle in its own right in traffic.

These futuristic machines are not without flaws (Stofers, 2019). In an urban environment, the low position of the driver does not allow him to see above the cars. The fairly heavy weight of the bicycle (25 to 50 kg depending on the model) does not make it very effective in rough terrain or in the event of frequent stops (but it may include electrical assistance). Its size also makes it more difficult to park. These vehicles, manufactured in a traditional way, are still expensive, but prices will fall as the series lengthens. However, this equipment needs to be democratized. For the time being, however, these bicycles suffer from their low notoriety, and for good reason: the International Cycling Union excluded them from sports competitions in 1933 for excessive performance! (Teniska et al., 2004)

Until these technological marvels are within everyone's reach, the efficiency, reliability and comfort of the city bike can still improve, with, as standard, stronger tires, safer brakes, a transmission that is better protected from bad weather and dust, gears that are easier to shift, more powerful and reliable lighting, a stronger luggage rack, a more ergonomic seat, a lighter overall weight, etc. Finally, the design of the bikes, cyclists' equipment and accessories will continue to evolve according to needs and fashions.

This profusion of new materials and innovations will create a dynamic technological universe and a new way of life - far from the return of the candle - which can already be seen in the Netherlands or Denmark (Copenhagenize). 250 in France, where Décathlon (more than 30% of the market alone), Go Sport and mass distribution are driving down prices and quality (Mercat, 2009). In short, the bicycle will once again become a symbol of modernity, inventiveness and freedom, as it was at the end of the 19th century, albeit with more efficient, more varied and less expensive equipment.

1.8.7. Effervescence

The utility bike will not be returned on a regular basis. Steps will be taken; slowdowns will follow runaways. As long as the bike system remains incomplete or poorly performing, the practice will have a hard time developing. But as soon as the bicycle network becomes sufficiently meshed and safe, as soon as it is easier to find bicycles that are really adapted to utility trips, as soon as there are repairers in most neighbourhoods, the practice will accelerate, as is already the case in many European cities. A certain confidence will be established, fashion and mimicry will appear, especially among young people, and a new standard of behaviour will take shape. What used to be considered offbeat, even laughable or old-fashioned, will suddenly become desirable and modern.

A new generation of elected officials and technicians who are more open to active modes should also accelerate the adoption of ambitious cycling city policies. Previously unthinkable decisions will suddenly become obvious and commonplace. Beyond the inertia that is always highlighted, the world of urban travel is accustomed to these accelerations, often fostered by unexpected external events, as was the case with the craze for urban courtyards in the Netherlands, then for traffic calming in Germany, the exceptional success of limited-traffic areas in Italy or the unexpected return of light rail in France.

The case of "participative and solidarity bicycle workshops" is a good example. In these workshops, at a schedule agreed upon in advance, everyone comes with his or her bike to be repaired and everyone helps each other by taking advantage of the expertise of the best handymen, some of whom end up becoming permanent volunteer workshop facilitators. This collaborative experience is useful, economical and very user-friendly. The workshops also strive to recover and recycle unused or degraded bikes, participating in the recovery of waste, while providing work for a reintegrated workforce, with resold second-hand bikes partially financing the activity. The success of these workshops is such that a French-speaking associative network was created in 2008, “The happy cycling” (“L'heureux cyclage”), which already includes about a hundred workshops at the beginning of 2014, in France, Wallonia and French-speaking Switzerland.

It is therefore perfectly possible that countries lagging behind, such as France, the United Kingdom or Spain, are also experiencing boom times for cycling in cities, with no doubt a shift to traffic calming, as the latest developments seem to suggest. A few pioneering cities will play the role of locomotive. In France, it will surely be Strasbourg, but also Bordeaux and Grenoble, and even Nantes or Paris. Among medium-sized cities, La Rochelle and Colmar are beginning to realize their lead and should consolidate it by arousing envy.

In forty years, it is likely that the European countries lagging furthest behind in terms of utility bicycles will have made great progress. Some cities will even have achieved that more than half of all urban trips are made by bicycle. Cycling will have returned to being a common and popular mode of travel, used unashamedly by all sections of society, for all types of trips, at all ages and for all purposes, not without subtle differences in equipment and practice that will always allow social classes to distinguish themselves.

Multiple, very astonishing "subcultures" will develop. For some, the bicycle will become a cult of effort and endurance: think of the bicycle couriers in all the major cities of the world (Bréard, 2011). For others, the bicycle will become a cult of effort and endurance. 45 For others, it will become a support for DIY or for learning mechanics. Still others will see it as an opportunity to develop their sense of skill and balance by trying out unicycle or BMX. Some will use it as an electricity generator, using volunteers to pedal, like this Californian rock band - The Ginger Ninjas - during their concerts. Some parents will be excited about the various transportation solutions for their children.

Retro or futuristic bicycle enthusiasts will organize themselves in clubs or brotherhoods. Some cyclists will customize their vehicle according to the latest trends or will succumb to the new products of the biggest luxury brands: Chanel, Hermès or Gucci already offer superb models. Weddings with arrival and departure in luxurious tandem or in a flowery rickshaw will multiply...

Conclusion, the bicycle, a choice of society

All European countries and Japan are today engaged in a movement of moderation of traffic and return to the bicycle, which began thirty-five years ago in the Netherlands, then in Denmark, Germany and Flanders, twenty-five years ago in Switzerland and Northern Italy, and ten to fifteen years ago in France, the United Kingdom, Wallonia and Spain. This movement is even worldwide, since similar trends can be observed in North America, South America and Oceania (Horton et al., 2012).

But the authorities have not everywhere taken the right measure of the population's aspirations to return to this mode of travel with its many virtues. The French, for example, are rapidly changing their relationship with the automobile and have never been more in favour of bicycles (CVTC, 2012). They undoubtedly feel that it is a real response to the economic and environmental challenges facing the cities of the 21st century. Certainly not by simply building a few bicycle facilities here and there or inaugurating a self-service bicycle system. The necessary ambition is quite different: cities need to develop a green transportation system combining walking, cycling, public transit and carpooling, in which the bicycle plays a pivotal role by increasing the efficiency of walking while limiting costly investments in public transit.

The success of such a project depends, however - and this is a major lesson of our historical study - on a firm policy of traffic calming. While some still claim that such a policy leads to economic decline, (Poulit, 2005) the decline is now sufficient to show that “slow cities” - where traffic has been calmed down - are no more economically difficult than others. A peaceful urban environment is also a factor of attractiveness.

The question does not arise in terms of free choice of mode of travel, as one might think. Since most urban travel can be done by means other than cars or motorized two-wheelers, restricting motorized travel a little is not an infringement on freedom of movement. The objective is simply to anticipate and adapt as well as possible, and without delay, to current economic changes and the depletion of resources in the future. These changes will have consequences far more constraining than a few speed, traffic or parking limits.

Of course, it is not the most resisting people who will be the first to use bicycles, but first of all those who are most sensitive to its arguments, the phenomenon then gradually spreading from the centre to the outskirts of cities, from the urban elites to the middle classes and the working class. As the youngest people are less apprehensive about cycling than those for whom access to the car has been a conquest, this change will also take place through generational renewal.

If the trend is towards a European (and no doubt global) convergence of urban transport policies, the role of local and national authorities is at least to be in tune with this evolution, by remaining attentive and open to current events. They must then propose, with courage and lucidity, coherent policies around a clear vision of what peaceful cities can be and must submit these orientations to democratic debate. In order to avoid endless debate on the means to achieve this, the objectives must be agreed upon beforehand.

Adopting a bicycle is much more than a simple modal choice, it is also a choice for a more balanced travel policy, better control of public finances, a fairer lifestyle and a more convivial way of life. It is, in short, a societal choice.

Chapter 2

Bicycle and public transport intermodality practices

The growing concern of the organizing authorities to think about all of the mobility flows in the territory, and no longer only the subjects of public transport, is obviously a paradigm shift, which we can only welcome. It is indeed more than time to leave the vain quarrels which oppose car and public transport, or public transport versus bikes. It is through a comprehensive approach to mobility issues that communities will fight more effectively against pollution and congestion in city centres.

In France, the law of Modernization of the territorial public action and affirmation of the metropolises (MAPTAM) enacted in 2014 works in this direction, the transition from a transport approach to a mobility approach by transforming the Urban Transport Organizing Authorities (AOTU) into Mobility Organizing Authorities (AOM). From now on, the AOM is responsible for the management of public transport, but also for the development of all other alternative modes and uses. It is his responsibility to make them complementary and to interconnect them as best as possible to enhance their effectiveness. In addition, this law established Regional Intermodality Schemes (SRI), which should take into account the bicycle as a fully-fledged component of the mobility offer developed by local authorities.

In Japan, in the decade from 1965 to 1975, traffic regulations were relaxed to allow cyclists to ride on the sidewalks. Since then, bicycle & pedestrian tracks have gradually been provided so that bicycles are separated from automobiles. Since cyclists tended to overlook the danger of bicycles as a type of wheeled vehicles, there was an increasing number of dangers when bicyclists rode on the sidewalks. It was necessary to implement countermeasures in order to reduce bicycle and pedestrian accidents. In 2007, MLIT and the National Police Agency designated 98 districts across the country as "bicycle road model districts" (hereinafter referred to as "model districts") in which bicycle road / bicycle lane development would occur. In October 2011, the NPA decided that it would let people know that bicycles are a wheeled vehicle and they would carry out comprehensive safety programs for cyclists and pedestrians. In the same year, MLIT and the NPA created an investigative committee to provide a safe and pleasant cycling environment. In April 2012, the Committee filed the "Recommendation for safe and pleasant cycling environment for everyone" (hereinafter referred to as the "Recommendation") with both MLIT and the NPA. In November 2012, in response to the Recommendation, MLIT and the NPA jointly developed "A guideline for creating a safe and pleasant cycling environment" to help road administrators and prefectural police to engage in planning and developing road networks for cyclists and to raise awareness of traffic laws.

The development of the bicycle is all the more essential as it participates in the implementation of effective sustainable mobility policies aimed at improving air quality and combating climate change. It also makes it possible to rebalance the sharing of roads for the benefit of non-motorized modes, to satisfy the principle of "right to mobility" and, finally, to bring a major gain in terms of public health.

The potential of the bicycle is greatest in a multimodal travel chain. This is why local authorities are increasingly instituting policies which encourage intermodal practices, combining cycling and public transport: cycle roads and bicycle services connected with the transport offer, secure bicycle parking near public transport stations, multimodal information, common ticketing support, combined pricing, bicycle boarding, etc.

It is the whole point of this chapter to highlight the levers that allow a better articulation of the intermodality of bikes and public transport. The measures raised in this research does not apply uniformly to all of the territories, but they are capable of increasing the use of these two modes combined, from which elected officials and technicians of the communities can draw depending on the dynamics of their respective territory.

This chapter wants to shed light on the importance of cooperation between local and regional authorities for a good articulation of mobility policies carried out on the scale of the regional territory. This is the message that both engineers and policymakers have been defending for years to enhance the attractiveness of sustainable mobility.

Introduction

For several decades, the development of public transport and its attractiveness has been the common thread running through the mobility policies of most transport organising authorities. After decades of rapid motorization from the 1950s to 1970s, more and more policymakers raised their voices to express the absolute necessity to strictly limit the use of private cars for certain journeys if we want to save our cities from asphyxiation and develop public transport and non-motorized means of transport.

However, the last few years have shown us that the development of public transport infrastructure alone is not enough to create a viable alternative to "solo-driving" at any point in the territory. The traditional work on the development of transport supply implies a simultaneous action on demand. From this perspective, communities have considerably diversified their actions so as to deploy a range of mobility solutions between which citizens can arbitrate to make their journeys.

In particular, they have taken a great many initiatives in favour of the development of cycling, by introducing measures in an ever-increasing variety of forms designed to promote its use. The law enacted in 2014 in France on the Modernisation of territorial public action and the affirmation of metropolises (MAPTAM) endorsed this change in practices by transforming the Urban Transport Organising Authorities (AOTU) into Mobility Organising Authorities (AOM) and by establishing Regional Intermodality Schemes (SRI). The aim of these two major provisions is to facilitate the creation of interconnected packages of mobility solutions, aided by technological advances.

In this context, this chapter seeks to identify the necessary updates regarding the links between cycling and public transport, in order to carry out a comprehensive inventory of actions to facilitate intermodality between these two modes of transport that are structuring for sustainable mobility.

For France, this approach wants to highlight the work carried out for many years by the CEREMA, the CVTC and the FUB. For Japan, the work has been mainly carried out by MLIT and NPA.

This chapter is about the following questions:

- What contribution does the bicycle make to a strategy for developing a bouquet of interconnected mobility solutions?
- What actions can transport organising authorities in Europe and Japan undertake to encourage intermodal cycling and public transport practices?
- How can a transport organising authority carry out these actions, and what is the feasibility of such an approach?

This chapter aims to answer these questions in three parts, the respective aims of which are to explain the reasons why we wished to study bicycle-public transport intermodality (1), to present the intermodality actions implemented today by local authorities (2) and to identify the determining factors in the effectiveness of these actions (3).

Studying bicycle-public transport intermodality policies and their determinants: methodology

Today, the advantages of intermodality between bicycles and public transport in providing an alternative to single-person car journeys are clearly identified. More and more local authorities are therefore implementing policies to encourage these intermodal practices. Previously mainly targeting the access of bicycles in public transport in large conurbations, these policies are now taking increasingly varied forms in communities with ever more diverse profiles by rank and size.

The aim of this chapter is to analyse the actions implemented to better link the use of bicycles and public transport. In addition, it seeks to study the determinants of these intermodality measures, which either favour or hinder their effectiveness.

Moreover, the purpose of this study must be placed in the context of the laws of MAPTAM for France and NPA for Japan. In France, MAPTAM law transforms the AOTU in AOM, thereby establishing a shift from a transport approach to a mobility approach. From now on, the AOM is in charge of organising a global alternative to single-person car journeys, which includes not only the management of public transport, but also the development of all other alternative modes and uses: car sharing, car-pooling and active modes including cycling. It is within its remit to make them complementary and to interconnect them as well as possible in order to enhance their efficiency. The MAPTAM law makes the region emerge as a leader in intermodality between all modes, in particular through the development of regional intermodality schemes. In this context, the study of actions and factors of bicycle-transport intermodality should make it possible to draw lessons that can be transposed to the development of intermodality involving all modes.

2.1. Why study bike-transport intermodality?

Driven by increasingly ambitious mobility planning documents, policies aiming to increase the use of alternative modes than individual car use have multiplied in recent years in both Europe and Japan. They have been democratised throughout the two areas and are no longer the prerogative of large conurbations with highly networked transport networks. The effectiveness of these actions necessarily requires the creation of a global mobility system, a “bicycle system”. In this system, each mode of transport has its own “zone of relevance” and the attention taken in switching from one mode to another guarantees their attractiveness.

The development of bicycle use fully participates in the implementation of effective sustainable mobility policies. Local and regional authorities may decide to promote its development in order to achieve the following objectives.

2.1.1. Improving air quality and combating climate change

The modal shift from car to bicycle for daily commuting to work 5km away would prevent the emission of 650 kg of CO_2 annually (Schweizer et al., 2013). Furthermore, the transport sector accounted in 2012 for 16% of national fine particulate matter (PM 10) emissions and 59% of national nitrogen oxide emissions in Europe, the vast majority of which came from road transport (CITEPA, SECTEN). The transport sector is also the largest contributor to the CO_2 emissions in both Europe and Japan. It is not difficult to imagine the gains in terms of air quality preservation that would be achieved by a modal shift of even a small percentage from private cars to bicycles.

2.1.2. Rebalancing the sharing of roads in favour of non-motorised modes of transport

The development of bicycle use corresponds to a choice of urban planning. For example, it may involve reclaiming public space previously dedicated to private cars (roads, parking spaces, etc.) and allocating its use to cycling, walking and other active modes (scooters, personal transporters, etc.). In so doing, the local authority is affirming its desire not to abandon public space to the car, which in many areas has often been confiscated.

2.1.3. Developing mobility solutions at a sustainable cost

Cycling is a complement to public transport and its introduction is relatively inexpensive compared to the deployment of heavy transport infrastructure (streetcar, high-service buses, etc.). The cost of developing one linear metre of cycle lanes is in fact around €60 to €700 (¥7000 to ¥80 000) excluding taxes, depending on the nature of the road (track, lane, mixed bus-bike corridor, etc.), the work it requires (resurfacing, etc.) or its characteristics (surfacing, etc.)

The investment cost of a streetcar project (infrastructure and rolling stock) amounts between €16,000 and €25,000 per metre (between ¥2M and ¥3M), while the same cost for a Bus Rapid Transit (BRT) project is: €1,000 to €4,000 per metre (¥120 000 to ¥480 000) for a BRT with 30 to 50% exclusive right-of-way, €4,000 to €7,000 per metre (¥480 000 to ¥840 000) for a BRT with 50 to 100% exclusive right-of-way (GART, CEREMA).

2.1.4. Promoting social inclusion and fulfilling the principle of the "right to mobility"

The bicycle is an economical means of getting around, especially in comparison to the car, which has significant costs in terms of vehicle purchase and maintenance, refuelling and access to a driver's licence. The FUB has calculated that a daily bicycle trip of 10 km would cost 100 euros per year, compared to a cost of around €1000 (¥120 000) per year for the same trip by private car

(FUB, 2013) This makes cycling a financially accessible mode of transport, independent, moreover, of the evolution of energy costs.

However, there is unequal access to bicycles in some areas due to a lack of training in cycling. To overcome this obstacle, many associations have set up bicycle schools, such as in the Chambéry conurbation where the association "Ecomobility agency" in France or Japanese cycling embassy in Japan offers residents the opportunity to learn how to use a bicycle.

2.1.5. Improving public health

The positive health impact of the use of bicycles for everyday travel should also be highlighted. Indeed, its use is precisely in line with the results recalled by the French National Institute for Health and Medical Research (INSERM): 20 minutes of physical activity three times a week reduces the risk of mortality by about 30% compared to being inactive (Leitzmann, 2007).

However, measures targeting the development of cycling, such as the deployment of a structured network of cycle paths or the establishment of a bicycle rental service, cannot succeed in establishing a viable alternative to single-person car trips if they do not address cycling in close connection with other modes of travel. Indeed, it is in a multimodal transport chain that the potential of the bicycle for sustainable mobility is the greatest.

The main challenge for local authorities is therefore to introduce policies that encourage intermodal practices, particularly by combining cycling and public transport, and to make these practices competitive with car use (speed, comfort, ease of use, etc.).

These intermodality policies can take several forms: cycle lanes and bicycle services connected with the public transport offer, secure bicycle parking near public transport stations, multimodal information, common ticketing support, combined pricing, bicycle boarding on public transport, etc. They extend the reach of public transport as well as that of the bicycle, by giving users more means to get to the stops on public transport lines.

Thanks to cycling, the zone of influence of public transport lines is considerably wider than it would be if one could only walk to their stops. They thus offer users a credible alternative to the use of cars on all their journeys. It should be pointed out that the connection of bicycles and public transport is particularly interesting to meet travel needs in sparsely populated and rural areas, which are often poorly served by public transport and which, in these areas, cannot be both economically viable and competitive with the car.

An enlightening example of the evolution of services in a business park in Angers in the west of France. Until very recently, this area was directly served by a bus line that was unattractive because of its slowness, which encouraged single-person car trips. However, an express line passed close to the area, but not close enough to reach the activity zone on foot from the stop of this line. In order to make this intermodality possible and strengthen the competitiveness of the bus line in the eyes of the employees of the business park, the urban community has set up secure, covered individual bicycle parking spaces near the line. This action is part of a wider programme to develop around 150 individual bicycle boxes around the business parks and residential areas far from the public transport network. This offer currently has a fill rate of around 50%. In addition, the intermodality between bicycles and public transport makes it possible to optimise the operating conditions of a public transport network. On the one hand, it can support an operation to overhaul the network. For example, during the revision of its Urban Transport Plan (PDU) approved in 2011, Nantes

Métropole chose to rationalise the transport offer to improve its performance. In this context, the bicycle has been identified as a particularly effective means of getting to these structuring lines. For its part, the Loire-Atlantique Departmental Council wanted to improve the operation of its interurban lines by developing express coach lines with high frequencies and a reduced number of stops in order to guarantee attractive journey times for users. To accompany this orientation, the local authority wishes to deploy a network of cycle paths or routes converging on the stops of these lines, where bicycle parking has also been installed and saturation have already been observed. On the other hand, intermodality policies can make it possible to regulate the different travel practices to ensure their harmonious cohabitation. For example, this can take the form of improved conditions for loading bicycles on board public transport, through the development of dedicated spaces (bicycle racks, bicycle vans, etc.). The Centre-Val de Loire region are thus financing the Train Vélo Loire service, during the summer months, which enables cyclists to board their bikes in a dedicated car (which can accommodate up to 40 bikes). Boarding and disembarking are carried out by SNCF (French railway company) staff, and the service is free of charge for users presenting their usual ticket. Generally speaking, European local authorities that allow boarding are careful to regulate it in order to minimise any potentially negative impact it might have on the line's operating conditions during rush hours. Indeed, at times when residual capacity is low, boarding conventional bicycles can raise issues of safety and regularity, and lead to conflicts of use. This is why some local authorities, such as the Alsace region, tend to limit the possibilities of boarding their regional trains and give priority to the installation of secure or covered bicycle parking areas near stations. However, considering the very high occupancy rate of Japanese railways, such a measure is only applicable for remote lines in countryside or focused on tourism such as the new BBBase line between Tokyo and Chiba.

Finally, it should be noted that the issue of intermodality between bicycles and public transport does not arise in the same way depending on the size of the urban area, in either Europe or Japan. It can be seen that in the densest areas of medium-sized urban areas, unlike in the city centres of large cities, the measures put in place are aimed more at the emergence of multimodal practices as an alternative to single-person car trips, rather than achieving very high levels of intermodality. This is particularly the case in Grand Chalon in France, which, on the one hand, promotes its bus services and, on the other hand, develops infrastructures dedicated to cycling (bicycle shelters, cycle paths, etc.). The agglomeration and the city centre are also considering adapting the traffic rules in the centre of the urban area to cyclists, possibly by generalising the double cycle lane and the right-hand turn for cyclists. The connection of these two modes also exists at major urban traffic hubs, but does not represent a development priority for travel in dense areas. This approach can be explained by the fact that travel distances in the centres of such urban areas are limited and therefore travel times are reduced. The use of only one of the two modes (bicycle or public transport) is therefore more suitable for this type of journey than the use of bicycle-public transport intermodality, which would imply a change for passengers, adding too much travel time.

Instead, these authorities are seeking to organise intermodal practices in their peri-urban areas and rural fringes, notably through the establishment of park-and-ride facilities, where intermodality is more between bicycles and private cars or between public transport and private cars than between bicycles and public transport. In Chambéry métropole, for example, the installation of secure bicycle shelters on car parks located at the gates of the urban area enables users to reach the park by car from their homes, before entering the dense part of the urban area by bicycle. In addition, as the living areas and home-to-work journeys generally extend far beyond the administrative perimeter of these urban areas, the question of intermodality is particularly relevant to the bike-train and bike-car link. Thus, the proximity of Chalon-sur-Saône to the employment areas of Dijon, Mâcon, Villefranche-sur-Saône and Lyon has a strong influence on the nature of the home-work journeys made by the inhabitants of the Chalon-sur-Saône urban area, who use the rail network on a daily basis after having switched to it by bicycle, foot or car.

Multimodality should not be confused with intermodality. Unlike intermodality, which characterises the combined use of several modes of transport for a single journey, multimodality characterises the practice of an individual using several modes of transport on a regular basis to make his or her journeys. Some local authorities initially choose to develop multimodal use by influencing behaviour to reduce gradually the single-person car trip reflex of residents. Once these multimodal practices are anchored in travel habits, they are more likely to be followed by intermodal practices combining the car and another mode of transport, or even to lead to intermodal journeys where the car is totally absent, such as bicycle/communal transport, walking/communal transport, etc. Intermodality can therefore be considered as a particular form of multimodality.

Large urban areas see more intermodality issues within their dense spaces. Here, modal shift has less impact on travel time as the total travel time is higher. It may therefore be attractive to make the first part of the journey using a structuring public transport line (train, metro, streetcar), then use a bicycle for the last kilometre of the journey, or vice versa. Let us therefore remember that the development of links between bicycles and public transport is one of the most effective levers for pursuing the objectives of sustainable mobility. By widening the areas of relevance for public transport and cycling, bicycle-public transport intermodality policies give users the means to change their practices and reduce their reliance on single-person car journeys. They also make it possible to overhaul a public transport network to make it more efficient. They also aim to enhance the organization of existing intermodal practices in order to improve the quality of service offered to all users. However, these policies cannot be understood in the same way in all territories. For example, large urban areas tend to focus on developing intermodality in their dense areas. On the other hand, medium-sized urban areas are more interested in the development of multimodality in their centres and intermodality in their peri-urban and rural fringes, or even on the scale of the catchment area beyond their administrative perimeters.

2.2. Intermodal actions already implemented today

Local and regional authorities in Europe and Japan have already implemented numerous actions of various kinds in favour of cycling and public transport intermodality. These actions appeared to be all the more effective to us as their design was accompanied by a search for complementarity and coherence.

We have chosen to group these actions into three categories:
- the creation of the infrastructures necessary for the physical implementation of bike-public transport intermodality;
- services developed or supported by local authorities that allow cycling to flourish and have an intermodal component;
- incentives of any kind aimed at the combined use of cycling and public transport.

2.2.1. Deployment of infrastructure to improve bike-public transport intermodality

Intermodality initially involves the development of infrastructure to ensure the smoothest possible transition from one mode to another. In the context of bike-public transport intermodality, this involves setting up in the majority of cases a high quality and wisely located bike parking facility, creating lanes for non-motorised two-wheelers to be folded down to public transport stops, and creating the conditions for the safe boarding of bikes on public transport equipment.

2.2.1.1. Bicycle parking

All communities that have embarked on ambitious bicycle development policies have installed dedicated parking spaces. A parking offer is properly deployed is a major factor in promoting intermodality with public transport. Local authorities must have a finely calibrated parking offer, taking into account existing flows and likely to accommodate future users. It should be noted that the impact of poorly sized parking facilities on the image and use of bicycles is very significant. Indeed, an offer that is too heavily dimensioned results in empty parking lots, which is responsible for a feeling of insecurity for cyclists who are reluctant to leave their bikes there. On the other hand, an overly limited offer leads to major parking difficulties, discourages some users from using their bikes or to park them in the street, an illegal practice in Japan with a strict enforcement. In the French city Toulouse, the large number of bicycle parking spaces installed by the metropolis and the Tisséo-SMTC public transport authority (Syndicat Mixte des Transports en Commun Tisséo-SMTC) makes it possible to meet a strong demand. When it is difficult to assess the demand for parking spaces in detail, it is possible to opt for mobile solutions, as Angers Loire Métropole has done In fact, the urban area has chosen to install light and mobile secure bicycle parking facilities as of 2010-2011, so that their location can be adjusted each year according to observed traffic. The deployment of bicycle parking spaces near public transport stops is an essential prerequisite for any intermodal policy. These parking spaces can take several forms: batteries of covered or uncovered roll bars, closed and secure car parks, roll bars with a security system, spaces integrated into a bicycle station, public bike share (PBS), etc. The term "bicycle station" defines a centre for bicycle-related services including reception by dedicated staff. It generally offers guarding, short-term and long-term rental, and other ancillary services. Self-service bicycle systems (PBS), on the other hand, consist of short-term bicycle rental, using automated stations accessible 24 hours a day.

Regarding Europe, it should be noted that conventional, arch-type parking spaces are generally located evenly throughout the territory, without giving priority to proximity to public transport stops rather than to places where people live and do business (government offices, city centre shops, etc.). On the other hand, the location of bicycle stations and self-service bicycle stations is very often determined according to intermodality criteria. Bicycle stations and bicycle-sharing systems are therefore mainly designed as structural tools for the deployment of bike-public transport intermodality. One possible explanation is undoubtedly the fact that their development has greatly accelerated in recent years and that they have been considered by local authorities as a marker of the evolution of their practices towards intermodal mobility.

In addition, the "observatory of active mobility 2014" of the Cycling cities and territories club tells us that in 61 urban areas and cities, 30% of the parking supply excluding hoops is made up of "bicycle garages kept at the central station". This trend is stronger in areas with 100 000 to 250 000 inhabitants (38% of the off-carrier parking offer) but is also true in other categories of areas where this type of parking constitutes between 23% and 31% of the off-carrier parking offer.

In addition to the simple criteria of proximity, some local authorities have chosen to secure and shelter certain bicycle parking spaces located near public transport stops so that users agree to park their bicycles for extended periods, generally all day or all night. We are thus witnessing the emergence of bicycle parking in the form of closed boxes with secure access, as for example in the Chambéry urban area, where individual closed boxes with 10 places and collective shelters with 50 places have been installed. This system is complemented by a 200-seat locker located near the station.

These three types of parking are accessible with a key for individual parking or a badge for collective parking, and are available 24 hours a day, 7 days a week. Their security provides protection against theft and vandalism, while their sheltered nature protects bicycles from the weather, making this offer very attractive.

In the European metropolis of Lille, secure bicycle parking has played a major role in increasing the use of this service. In addition, it has facilitated the practice of intermodality between bicycles and public transport in the central cities, since most of the secure parking spaces have been installed near public transport stops.

2.2.1.2. Cycling accessibility to mass transit

In order to allow intermodality between bicycles and public transport, it is important to organise easy cycle access to transport stations.

In this respect, French local authorities are creating so-called feeder cycle routes to enable cyclists to reach public transport stations. Usually in the form of cycle paths or lanes, these infrastructures can be accompanied by precise signposts indicating how to get to the nearest station or transport station. For example, one of the central elements of Toulouse Métropole's cycling policy is to create and adjust the cycling network so that it converges with the metro stations of the Tisséo- SMTC network.

At first glance, this action is the prerogative of French local authorities, which are both AOTs and “traditional” road managers. However, in particular configurations, other AOTs are in a position to take action in this field. This is notably the case of Chambéry metropolitan area, which has been transferred responsibility for the development and maintenance of cycle routes on all roads in the urban area, apart from two greenways which remain the responsibility of the Savoie Departmental Council. Alternatively, some AOTs also encourage the creation of such infrastructure through subsidies.

On the other hand, the added value of facilities encouraging the circulation of bicycles in stations to parking spaces or to platforms when bicycles are loaded onto trains should be emphasised. For example, the installation of ramps or chutes at the level of stairs makes it easier for cyclists to cross railway tracks, provided that the gradient is moderate.

2.2.1.3. The arrangements for boarding bicycles on public transport

While the boarding of bicycles on public transport is often perceived as detrimental to the efficiency of the public transport network, a significant portion of AOM allows this boarding.

These authorities consider that the benefit of this practice for the development of cycling and public transport use compensates for the risk of conflicts of use that may arise. However, the policy on the boarding of bicycles covers a wide range of realities. Indeed, the actions of local authorities differ greatly in terms of the type of equipment on board which boarding is authorised or not, and the types of restrictions placed on the boarding of bicycles when it is authorised. The regions now tend to limit the boarding of bicycles on TER trains and to encourage the parking of bicycles near stations. This trend should be seen in the context of the regions' desire to limit any negative impact of bicycle boarding, particularly at peak times, on train operating conditions.

For this reason, the deployment of secure bicycle parking facilities around stations has recently been stepped up both in Europe and Japan, and measures to regulate boarding on trains have generally been reinforced in France. It is virtually impossible to board any bicycle in Japan in most trains, too crowdy.

Some French regions have decided to allow bicycles to board only on a limited number of lines, outside peak hours, and subject to availability of bicycle spaces. For example, the Alsace region has until now authorised the boarding of bicycles, within the limit of available bicycle spaces, on all TERs except on 11 of them making the Strasbourg-Mulhouse-Basel journey on weekdays from 6am to 8.30am and from 4pm to 6.30pm. To improve the predictability of the journeys of cyclists who take their bicycles on board, it would seem important to extend to TER trains the possibility of reserving a bicycle space in advance of the train journey. It should be remembered that, following the Interdepartmental Action Plan for Active Modes (PAMA) this possibility is now open for trains with compulsory reservation. In addition, in order to limit the impact of bicycle boarding on train operating conditions while continuing to offer a boarding service, some regions are introducing various incentives to encourage the boarding of folding bicycles rather than conventional bicycle. The Pays de la Loire region has therefore introduced a subsidy for the purchase of folding bicycles strictly reserved for TER subscribers for home-to-work and home-study journeys, where congestion is most prevalent on trains.

Looking now at the results from CEREMA survey (2015) for urban transport, we see that the AOMs are endeavouring to develop intermodality, via boarding, first of all on their streetcar networks, then, to a lesser extent, on their metro networks, and occasionally on their bus networks.

It should be noted that the low proportion of AOMs allowing bicycles to board their buses may be explained by the need to apply for approval from the Regional Directorate of Environment, Planning and Housing (DREAL) before introducing this possibility. In addition, the size criteria of the AOM does not seem to explain whether boarding is authorised on the urban network (bus, streetcar, metro), nor the degree of supervision of boarding determined by each AOM. With regard to the latter, the survey shows that the AOMs that authorise boarding provide different levels of supervision depending on the mode of public transport concerned. Thus, while most AOMs allowing boarding on trams allow both conventional bicycles and folding bicycles to access the service, all of them impose restrictive conditions on boarding for conventional bicycles, linked to the residual capacity of trams. This trend is aimed at improving the cohabitation of users and ensuring the best service for all. In general, the restrictions are based on a time limit.

For example, Tour(s) plus allows conventional bicycles to be taken on board the tram during off-peak hours (i.e. outside the 7 to 9 a.m. and 4 to 7 p.m. time slots) and on Sundays all day long, except during peak periods. On the other hand, the European Metropolis of Lille prefers to make this same type of boarding possible at any time, but prohibits the boarding and alighting of bicycles at the stations with the highest number of visitors (Lille-Flanders...). In order to optimise space, the Nancy streetcar welcomes conventional bicycles during off-peak hours, and only in the absence of people with reduced mobility. On the other hand, folding bicycles are generally exempted from this set of rules, which encourages them to board. To accompany the shift in boarding practices towards folding bicycles, Nantes Métropole is also offering the "Cyclotan" service: this is a folding bicycle hire service reserved for subscribers to the Nantes public transport network. In the case of boarding on the metro, we note that this is more of an exemption to the principle of a boarding ban. This is alternatively granted only to folding bicycles, as in the European Metropolis of Lille and the Rouen-Normandie Metropolis, or granted to any type of bicycle but anecdotally. In Lyon, the SYTRAL fits into this second scenario, since it allows conventional bicycles to board a single metro line, outside rush hour and subject to availability of bicycle spaces.

Finally, some AOMs that authorise boarding on their buses are implementing other types of regulation for this boarding. First of all, they make little use of time restrictions and, for the majority of them, authorise the boarding of all types of bicycles. Indeed, the boarding of folding bicycles on buses does not stand out as a specific issue for consideration by these AOMs, which could lead to the introduction of incentives. Nantes Métropole is an exception to this observation by promoting its Cyclotan solution for the boarding of bicycles on the entire urban network. On the other hand, these AOMs authorising the boarding of conventional bicycles strictly delimit the spaces where bicycles can be stored on board buses, which probably needs to be brought into line with the requirements. Consequently, bicycles must either be placed on a rear rack outside the bus (Aubagne, Niort, Salon- de-Provence) or in a protected space, independent of passengers, inside the buses (Pompey, Nord-Basse-Terre). Due to the size of the facilities to be built and/or the specific nature of the boarding demand, boarding for conventional bicycles is often limited to a single line of the network. At Niort, for example, the possibility of boarding on a rear rack is offered on a single tourist line (Maraîchine line), in high season only.

The security conditions required to authorize the boarding of bicycles on public transit vehicles may differ from one territory to another. Generally speaking, loading bicycles on an outside rack attached to the front of the vehicle is considered dangerous and is therefore not authorized. It is also forbidden to place a bicycle rack inside vehicles in the central area reserved for people with reduced mobility and strollers.

Regional authorities and AOM tend to strongly regulate the loading of bicycles on board public transport in order to continue to offer an optimal service to all users. This regulation takes very different forms depending on the type of network and the type of bicycle concerned. The AOMs give priority to allowing bicycles to be taken on board trams, with a strong timetable framework for the boarding of conventional bicycles, which encourages the boarding of folding rather than conventional bicycles. Boarding on buses is rarely allowed, usually without incentives for folding bicycles, and favours space regulations rather than time regulations.

2.2.2. Bicycle or public transport services with an intermodal component

Bike-public transport intermodality can also be promoted through the implementation of services designed to alternatively develop the use of bicycles or public transport, to which an intermodal component is added.

2.2.2.1. The rental of bicycles organised in connection with public transport networks

The introduction of a bicycle rental service or a self-service bicycle hire service can become a favourable action for bike-sharing intermodality when it is set up as a complement to the public transport network. It should be noted that this rental service will be all the more attractive for cycling, particularly in terms of intermodality, if it is part of a comprehensive range of bicycle services similar to those offered at many bicycle stations. More specifically, for this offer to be adapted to intermodal cyclists, it is important to carefully consider several criteria, including the location of the rental locations, but also the access times to these rental services. The introduction of incentives such as a common fare or ticketing support common to the public transport network and to this bicycle offer will also strengthen its attractiveness. In this respect, the results of CEREMA survey tell us that the majority of the communities that responded that they have bicycles with at least one rental service, have made their bicycle schedules correspond to the peak hours of public transport or even to a wider range of times.

By refining the analysis, we can see that hourly access to the offers of a bicycle station is different depending on the service concerned. For example, access to the parking service is often available over a very wide range of hours, while the rental service is accessible during peak public transport hours. While it is important that access to a long-term bicycle hire service coincides with public transport operating times, so that bicycles can be hired or returned and then borrowed, the added value of almost 24-hour access seems low, and its cost high. In addition, it is likely that more users will want to park their bicycles in a bike park at any time, rather than renting a bicycle for a medium or long period of time at any time. It should be noted that the cost of operating a 24-hour parking service is reduced in case of the existence of automated lockers.

Self-service bicycles must be analysed in a differentiated manner. Since they are by definition accessible 24 hours a day, it is mainly the criteria of station location, ticketing interoperability or fare incentives that will influence their effectiveness in terms of bike-public transport intermodality.

It is also important to point out that many local authorities do not consider the PBS, and its principle of short-term rental, as the most suitable response to the objectives of deploying intermodality. More specifically, the intermodality policies of medium-sized agglomerations are aimed more at low-density urban fringes where the bicycle must be used to access the public transit network to get to the centre of the agglomeration. The establishment of LSV stations in these low-density areas is not very relevant because the stations would be little used and very expensive. As in Chalon and Angers, these authorities often favour medium- or long-term rentals, coupled with the provision of quality parking spaces near public transport stations.

2.2.2.2. Information for users

Information campaigns initially launched to encourage the use of public transport or cycling, is gradually being seen as a means of encouraging intermodal cycling and public transport practices. Three main vectors of intermodal information are distinguished: the map, whether on paper or online, the journey planner and signage at the place of intermodality.

It emerged that the representation of public transport stations on cycle path and route maps was a fairly common practice. However, the information relating to bicycles on public transport network plans is more heterogeneous. Thirteen AOMs and the Midi-Pyrénées region told us that they include bicycle information on these plans. We note that among these 14 local authorities, all of the AOMs whose territory includes an LSV service (9 local authorities) include this offer on the public transport network plan. In addition, 4 out of the 7 local authorities with such a "bicycle" service in their territory and indicating to us that they include "bicycle" information on their public transport plans. In addition, the possibilities for bicycle parking other than PBS and bicycles are only occasionally represented, as only 6 of the 14 local authorities show them on the public transport plans. Furthermore, none of these 14 communities indicate that they include information on the bicycle network on this plan.

To explain these choices of representation, we can argue that bicycle parking is considered a more effective factor in intermodality than the development of a bicycle network, and that HSV has been developed by many communities as an intermodal service. However, it should be noted that, in some territories, this integration of the bicycle network with the public transit network may be hindered by constraints in terms of graphic representation. In fact, this plan is not always based on the actual configuration of the roadway, which is an indispensable element in the representation of the bicycle network. The fragmentation of skills in terms of mobility can also have negative impacts on obtaining the data needed to produce complete and updated information documents. In particular, the mobility organising authority is not necessarily at the origin of the deployment of cycle lanes, the management of cycle stations, or the implementation of cycle parking spaces. It therefore has only a very patchy knowledge of the information related to the cycling policy implemented in the conurbation. On the other hand, it should be noted that of the 9 BLS services that the respondent AOMs include on their public transport network plans, 6 are directly managed by the AOMs themselves, which makes it easier to obtain the data.

In addition, for areas with a large volume of "bicycle" and "public transport" data, the trip planner appears to be the tool best able to fully integrate bicycle and public transport information for a single trip: journey times, access to public transport network plans and cycle plans, information on parking and boarding possibilities, etc. Nevertheless, as with the intermodal plan, using this form of information involves aggregating the information held by the various authorities and updating the data very frequently.

As this topic was not the subject of CEREMA survey, we have no visibility on the intermodal use of such tools. At most, we note that nearly a quarter of the respondent authorities have a multimodal information portal that includes bicycle-related information, and which is likely to include an intermodal route planner (see graph on p. 40). These authorities correspond to three regions and fifteen AOMs of all sizes. However, a correlation is emerging between the size of these authorities and the perceived level of use of the information portal, although this should be treated with caution given the small sample size. For example, communities with more than one million inhabitants generally perceive that their portal is "heavily used", while below 250,000 inhabitants, communities perceive that it is "moderately used". For larger authorities with large volumes of "cycling" and "public transport" data, the portal may then appear to be a profitable investment to gather this information.

In addition, some local authorities that have a route planner integrate the bicycle into it. For example, the multimodal information centre (CIMM) for the Haute Garonne and the Toulouse urban area, administered by Tisséo-EPIC (operator of the Tisséo urban network in the Toulouse conurbation, organised on a public authority basis), includes the possibility of starting or finishing an urban public transport journey by personal bicycle or PBS. It indicates the location of the LSV stations, contains some data on the parking of personal bicycles, and makes it possible to visualize the entire intermodal route.

Finally, the deployment of appropriate signage at intermodal locations makes it possible to link the use of bicycles and public transit. The objective is to make the range of "bicycle" services and infrastructures (rental, parking, network, etc.) visible from the public transport stop, and vice versa, by means of signposts.

This is, for example, the case of the Saint-Lazare station in Paris where the location of the bicycle park and the self-service bicycle station is clearly marked (see photo above). It is also a question of providing information on public transport timetables and routes in terms of the "bicycle" offer. For example, the bicycle station at Toulouse's Matabiau station has screens displaying the timetables of the next trains.

2.2.3. Incentives for intermodal bicycle-transport journeys

The promotion of bike-transport intermodality practices also depends on the implementation of various incentives, which complement each other.

2.2.3.1. Easy access to bicycle services for public transport users

In order to assert the intermodal dimension of a parking or bicycle rental service, some local authorities provide public transport users with easy access to this service. In areas facing strong growth in bicycle use, the allocation of these facilities is intended to defuse any saturation of bicycle services that would be unfavourable to intermodal practices. Indeed, in order to secure their travel chain, intermodal users need a guarantee of access to intermodal services such as station parking, bicycle rental at public transport stations, or the withdrawal of a self-service bicycle near a station. This is why some local authorities choose to define a quota of spaces reserved for public transport users in their secure bicycle shelters. The Midi-Pyrénées region, for example, has reserved 600 of the 680 parking spaces at the Matabiau station in Toulouse for TER users who subscribe to this service.

These spaces can be accessed using the ticketing system that contains the TER pass, on which the bicycle station pass has been loaded. This decision was taken in a context of strong demand for bicycle parking in the station.

In Chambéry, cyclists must necessarily subscribe to the parking service if they wish to benefit from a designated space in one of the boxes set up near public transport stops. Here again, this system has been set up against a backdrop of rapid saturation of bicycle parking in the city. Although the subscription to the service is not directly conditional on holding a subscription to the public transport network, access conditions have been implemented to prevent these spaces from being used as bicycle garages by local residents and to ensure their use for intermodal purposes. Thus, residents living less than 400 m from each box cannot subscribe to this parking offer.

On the other hand, we sometimes note that this reservation of the bicycle parking offer to public transport users only is the result of legal precautions and not a response to a constraint in terms of mobility organisation. This practice can be observed when the construction of bicycle shelters is financed by the transport payment, particularly in the context of the creation of bicycle parking spaces along a new *exclusive right-of-way public transport line* (UPT/ERW). Consequently, the community may consider that the bicycle shelter should be an integral part of the public transport offer and therefore be reserved only for users of this network.

However, the demand for intermodal bicycle parking by these users may not be sufficient to fill the shelter, which is reserved for them out of legal certainty and not out of a desire to regulate the high pressure on this parking. It should now be noted that this legal uncertainty has been removed by article 51 of the law on the modernisation of public territorial action and the affirmation of metropolises (MAPTAM) amending article L. 2333-68 of the general code of territorial authorities. According to its terms, the transport payment may be allocated to "financing the investment and operating expenditure of any action falling within the remit of the mobility organising authorities". The transport payment can therefore finance both conventional public transport and the investments required to promote cycling, walking, car-sharing and car-pooling.

2.2.3.2. The price incentive

Measures to develop intermodal cycling and public transport practices also require the introduction of combined pricing between these two modes. In accordance with this principle, regular public transport users who wish to access a bicycle service benefit from advantageous fare conditions compared to the ordinary fare. For example, all TER subscribers in the Burgundy region benefited from a 50% reduction on the use of the bicycle station at Dijon station, before the tariff overhaul operation which raised the subscription rate to 1 euro per month or 10 euros per year for all subscribers (TER and Divia urban network). At Grand Chalon, the annual subscription to the PBS "Réflex" service is free for subscribers to the public transport network in the conurbation. The results of CEREMA survey point to the emergence of such practices in the AOMs, which seem to be concomitant with the development of a variety of bicycle services. On the other hand, the lack of responses from regional members does not allow to identify trends on this scale. Indeed, 25% of the responding AOMs (18 out of 72) are implementing combined bicycle and public transport pricing. This proportion, which is still low, can be explained by the diversity of actors involved in cycling and public transport. In Toulouse, for example, Tisséo-SMTC manages urban transport while PBS is a city service. In Lyon, SYTRAL plays this leading role, while the Lyon metropolitan area has developed the PBS offer. Consequently, the implementation of combined pricing requires a decisive preliminary work to establish pricing agreements between the managers of the different services.

In addition, all AOMs responding with combined pricing between these modes include a bicycle rental service, whether long-term rental (13 AOMs) or LSVs (9 out of 12 AOMs responding with such a service). Much less often does this combined pricing include a bicycle parking service (3 AOM out of 12 respondents). This is due to the fact that in many communities, intermodal bicycle parking is free for all, making it impossible to implement any kind of discount. In other areas, this parking is only open to public transport users, so there is no full fare for any user from which a discount would be made. This was until recently the case for the Tour(s) plus bicycle shelters, initially reserved for subscribers to the urban public transport network. These shelters were then opened to network users with a post-payment card: for the latter, access, considered as a connection, is free of charge in intermodal transport with the streetcar or bus, but charged at the price of a journey in the opposite case.

Moreover, the introduction of simple and homogeneous pricing for all intermodal bicycle services in a given area is also a lever for intermodality. In this respect, we can cite the example of the Burgundy region, which wished to unify the fares of its various intermodal bike parks and to harmonise, in conjunction with Greater Dijon, the fare for the bicycle parking at Dijon station with the fares of the bicycle parking facilities set up by the urban area along the streetcar. In addition to these fare incentives, setting up a one-stop shop offering both the possibility of buying a public transport ticket and access to a bicycle service is a low-cost and highly effective action in terms of promoting intermodality. This solution has already been implemented in several areas such as Caen, Nantes, Chambéry and Grenoble. In Caen, it is possible to top up one's subscription to the TER network at the "Maison du Vélo", a bicycle rental station that offers bike hire and a bike deposit service. In Nantes, the agency of the urban public transport operator issues public transport tickets as well as subscriptions to the city's PBS services and secure bike parks.

2.2.3.3. The implementation of a common ticketing medium

The development of a common ticketing support for public transport and bicycle services is a complementary lever to encourage intermodal practices. Nevertheless, it seems to be used less frequently than combined pricing, which may be explained by the technical complexity and high cost of such "ticketing "22.

However, we have observed its implementation in territories of different sizes: metropolises such as Lyon and Toulouse via Tisséo-SMTC, urban communities such as Nancy, Dunkirk and Dijon, but also communities of agglomerations such as Belfort, La Rochelle and Perpignan.

In the case of the Tisséo network, it should be noted that the "Pastel card", a common ticketing medium, includes a wide range of modes: it is possible to load subscriptions to the urban, departmental and regional transport networks, to the PBS service of the city of Toulouse, to the secure bicycle parking lots located in the Tisséo network exchange hubs and to the Citiz car-sharing network.

In addition, we note that in all of these areas there is an LSV offer, almost systematically added to the common ticketing support, which underlines the desire to give an intermodal dimension to this type of service. Moreover, the common ticketing medium can also be an effective tool for linking the use of secure intermodal parking and the use of public transport, as in the above-mentioned case of Toulouse, or in Perpignan, Nancy and Dijon.

Consequently, the more the medium takes into account the different components of the offer in terms of cycling and public transport, the more it provides an incentive for intermodality. Moreover, the ease of use of intermodal services that it allows is even greater if it is associated with the institution of combined pricing mechanisms, as we have seen in La Rochelle, Dunkirk, Toulouse, Nancy, Perpignan and Dijon.

2.3. Factors impacting the effectiveness of bicycle & public transport intermodality

The success of the various actions aimed at improving bicycle-transport intermodality is conditioned by the concomitance of several factors. Sometimes related to the modes of governance between local authorities, sometimes related to funding arrangements or to the role given to the operator of the public transport network, these factors may explain why the same action does not meet with the same success from one territory to another. We will present them starting with those that have the greatest impact on the effectiveness of the actions implemented, even if it is essential to bear in mind that some of them are highly interdependent.

2.3.1. Governance adapted to the deployment of intermodality

First of all, it should be noted that the AOT does not have a complete competence in cycling, which is moreover exercised by the AOT and which thus provides it with all the necessary levers to encourage intermodal cycling and public transport practices. A local authority wishing to implement an intermodal policy must therefore manage the dispersal of bicycle-related prerogatives (road, urban planning, public transport, special traffic and parking police powers, etc.) and the diversity of the entities holding these prerogatives. At the same time, on the scale of a catchment area, the efficiency of the organisation of intermodality is highly dependent on the cooperation of the various AOTs in the area. Moreover, the implementation of such intermodal actions also depends on the type of political and technical support existing within the local authorities. In view of all these constraints, governance arrangements appear to be an essential factor in the effectiveness of cycling-public transport intermodality policies.

2.3.1.1. Relations between institutional stakeholders

The effectiveness of intermodal bicycle - public transport actions is intrinsically linked to the quality of relations between institutional players of all ranks. Transport organising authorities, road managers, urban land authorities, etc. are all partners that must be mobilised together to implement an intermodal policy.

The functioning of inter-municipal cooperation

The configuration according to which all the competences impacting bicycle- public transport intermodality would be held within the same authority at the scale of the agglomeration does not exist today on any territory. However, this is one of the principles that guided the transformation of the AOTU into the AOM. However, for the AOM, whose "public transport" competence has been acquired, to take full advantage of their new "cycling" competence, they still lack the necessary expertise in terms of urban planning, road management, or even traffic and parking policing powers. This situation gives rise to the partnership nature of bike-public transport intermodality projects.

Thus, in practice, the implementation of intermodality actions depends on the agreement between an EPCI and its member municipalities to exercise the skills and powers affecting intermodality in a concerted manner. For example, an EPCI that is competent in mobility organisation but not competent in roads will have to enter into dialogue with the municipalities managing the roads in order to develop bicycle access to public transport stations and bicycle parking facilities in their vicinity. The same constraint arises when this EPCI is competent in road matters but only on the roadway of Community interest, and the cycle facilities it plans are located on the communal management roadway. Conversely, in the case of a metropolis or an urban community, the implementation of bicycle-transport intermodality measures is facilitated by the fact that these two types of EPCI have not only AOM competence but also competence for roads on all the roads that were previously in the communal public road domain. In order to facilitate the coordinated exercise of road and mobility organisation responsibilities, some EPCIs, when they are AOMs, may have their member municipalities transfer responsibility for the development and maintenance of cycle routes on all roads for which the municipalities are the road managers. This practice is made possible by the divisible nature of the road authority. However, it should be noted that the "bicycle roadways" prerogative acquired by these EPCIs does not allow them to develop bicycle parking lots, since these fall under the "street furniture" category and therefore continue to depend on the main roadway manager.

The implementation of actions of intermodality between bicycles and public transport also requires the mobilisation of skills relating to urban planning. For example, the local urban development plan (PLU) of a municipality, or of an EPCI when it is drawn up at the inter-municipal level, is an effective lever for planning cycle feeder routes to public transport stations, for establishing the "permeability" of plots in order to set up efficient cycle networks, or for securing sites near public transport stops intended for bicycle parking or the reception of bicycle services. On this point, the EPCI must therefore act in concert with the municipalities responsible for drawing up the PLU when the cycling policy is extended to the inter-municipal level. The same need for coordination applies when, on the other hand, a municipality wishes to carry out actions in the field of bicycle development and the EPCI of which it is a member is competent in matters of PLU.

In addition, several powers exercised by the local authority executive (mayor, president of EPCI) have an influence on the development of cycling and public transport intermodality. It therefore also depends on the coordination between the authority carrying out an intermodal project and the holders of these powers. On the one hand, the regulation of lane use is the responsibility of the special traffic and parking police, exercised by the mayors of the municipalities or by the presidents of EPCIs with their own tax system. Since the Act of 13 August 2004 on local freedoms and responsibilities, the latter may have this power transferred to them if their EPCI is competent in road matters.

It should be noted that this possibility of transfer has been reinforced by law. Recently, the MAPTAM law has made it automatic unless one or more mayors oppose it within six months of each new election of the EPCI president. Nevertheless, in general, the mayors wished to retain the exercise of this police power. In this capacity, they decide on the categories of vehicles authorised or not to circulate on all roads within the urban area. Moreover, since the MAPTAM Act, their power also applies to roads in the communal and inter-communal public road domain outside the urban area. Not all of them necessarily wish to use this power to allocate more space to cyclists to the detriment of other road users. This is why an AOM, even if it is also a road manager, must work in consultation with the mayors.

Moreover, infrastructure projects aimed at bicycle-transport intermodality are also subject to the issuance of a building permit by the competent authority, which is usually the mayor. This segmentation of roles makes the sharing of the bicycle/collective transport intermodality project all the more fundamental. As a counter-example, a refusal to issue a building permit may cause the installation of secure bicycle shelters designed to complement a UPT/ERW line to fail.

Moreover, the same bicycle-transport intermodality action can be carried out under two different competences, which reinforces the need for the AOM and the other local authorities in a territory to work to coordinate their initiatives. For example, a PBS service has been set up by Nantes Métropole as part of its AOM competence, while in Toulouse it was set up by the municipality, not the AOM. In the Angevin conurbation, secure parking facilities are deployed both at the initiative of AOM Angers Loire Métropole in the vicinity of bus stops, in cooperation with the municipalities concerned; and at the initiative of the city of Angers, via the Société d'aménagement de la région d'Angers (SARA), in car parks located in the immediate vicinity of the station. The station's secure bicycle parking facility is the result of collaboration between the city of Angers, Angers Loire Métropole and the Pays de la Loire region.

The existence of a shared service common to an EPCI and its city centre can help these two local authorities to ensure the consistency of their initiatives and the simultaneous exercise of their prerogatives relating to bike-transport intermodality. For example, the shared services between the city of Chalon-sur-Saône and the Grand Chalon conurbation community enable the latter not only to support the city's initiatives, as it does with its other member municipalities, but also to encourage the city to implement intermodal actions (bicycle parking, cycle routes, etc.).

Finally, the particular case of the delegation of AOM's competence to a joint transport union adds an additional degree of complexity to these institutional relations, since the relations between the joint union and its members (EPCI, municipalities, etc.) come into play. Thus, a joint transport association may be delegated the organisation of public transport, accompany this mission with the installation of bicycle arches around tram and bus stops, and must meet its legal obligations in terms of the development of cycle lanes when creating or renovating urban roads generated by the development of UPT/ERW (article L. 228-2 of the Environment Code), if necessary, in conjunction with the road manager.

At the same time, the conurbation that has delegated its authority to the UPT/ERW may continue to implement a cycling policy by providing secure facilities for safe deposit boxes at public transport stops and stations. At the same time, if the municipalities in the area are road managers and the mayors have the power to police traffic and parking, any municipality wishing to address the issue of intermodality can, in particular, install covered bicycle parking near bus stops and increase the number of double cycle lanes throughout its territory.

In this case, the articulation of the prerogatives of each party can lead to the superimposition of actions without any real overall coherence, which will have a negative impact on the efficiency of bicycle- public transport intermodality. On the other hand, if everyone's initiatives are co-ordinated, the implementation of actions by a joint transport association has the advantage of ensuring the coherence of cycle-public transport intermodality over a vast area. In Toulouse, for example, the Tisséo- SMTC joint transport union manages bicycle/collective transport intermodality over a wider area than Toulouse Métropole, while at the same time being part of a well-established governance system between the union, its member EPCIs and their municipalities. The existence of previous joint projects has provided a basis for this coordination: the European "Civitas Mobilis" programme thus made it possible to bring together the various institutions in 2005 to take stock of the current state of the practice of cycling in intermodality with public transport. Since then, the various players have become accustomed to working together on this subject. In addition, coordination is facilitated by the good working relationships that exist between the bicycle focal points of the different authorities. Finally, within the framework of its UPT/ERW projects, Tisséo-SMTC organises permanent coordination with the road managers in order to build continuities between the cycle route it develops along the UPT/ERW and the adjoining cycle route. Similarly, Toulouse Métropole meets with Tisséo-SMTC on a quarterly basis to discuss the intermodality of cycling and public transport, more particularly with a view to developing bicycle services at the city's main transport hubs.

Relations between AOM, department and region

Similarly, the need for coordination of initiatives is found at the level of the various transport organising authorities in a territory: region, department and AOM. This ensures that the actions carried out in a given area complement each other or have a leverage effect in developing intermodality between cycling and public transport. By way of illustration, the habit of coordinating Nantes Métropole and the Pays de la Loire region before any new measures are introduced has meant that the respective schemes of these authorities in favour of the use of folding bicycles on public transport have reached a large public of intermodal users. The conditions for renting the Cyclotan set by metropolitan France make it a tool for boarding on the urban public transport network, while the regional aid for the purchase of folding bicycles is intended for subscribers who board their bicycles on the TER network for home-work journeys.

The Burgundy region has initiated a regional conference of transport organising authorities which meets twice a year. Intermodality is a central theme: coordinated services, price consistency, and the link between cycling and public transport. In this context, the departments have been encouraged to accept the boarding of bicycles on board certain departmental coaches, which makes boarding policies in the region more transparent for users, just as the region has done for its own TER coaches. The Mobigo route planner, to which all the Burgundy AOTs subscribe, has been supplemented by a dedicated bicycle planner, with the agreement of all the partners who have provided the data related to the bicycle routes within their perimeter.

In addition, the management of the bicycles linked to the Dijon streetcar and the Dijon station bicycle station demonstrates a genuine desire to harmonise the offer of the various AOTs for the benefit of the user. It should be remembered that Greater Dijon co-finances the regional bicycle station in the station, and that subscribers to the urban public transport network, as well as certain subscribers to the TER network, benefit from a reduced fare to access it. In addition, the region has agreed to entrust the management of this bicycle station to the operator of the Dijon urban network, which manages the streetcar's bicycle stations. Finally, the two authorities wished to harmonise the subscription rates for their closed bicycle stations and bicycle shelters.

Conversely, the lack of coordination between the AOTs of a territory is likely to affect the legibility of the intermodal offer. This is particularly the case when an AOT develops a multimodal information portal that only integrates its own intermodal bike-transport services and not those of other AOTs in the territory. It is then up to the user to reconstitute the overall panorama of the intermodal offer available to him. Moreover, it can be complicated for the AOT to gather and regularly update all the data on its territory relating to the supply of intermodal public transport services by bicycle, since it does not necessarily hold the data itself. However, this data must necessarily be integrated into intermodal information media (maps, route planners, etc.) in order to ensure their usefulness and effective use by users.

AOT relations with road managers

Like most EPCIs, the departments are not necessarily managers of the roadway on which they wish to carry out intermodal cycling facilities with public transport. According to the current legislative framework, the region is never a road manager.

While this may appear to be an obstacle, many of these authorities manage to provide financial incentives to encourage the implementation of intermodal developments. At the same time, they are introducing rules to ensure that future developments will support the intermodality of cycling and public transport. This can in particular make it possible to mobilise the road skills of the local authorities managing the area concerned.

By way of illustration, the Centre-Val de Loire region is encouraging the deployment of bicycle parking facilities near stations by offering 40% funding for projects carried out under municipal and inter-municipal project management, and meeting the objectives of the 2009 regional cycling plan (any operation linked to the parking of bicycles in stations is likely to be co-funded: open or closed collective bicycle shelters, individual lockers, etc.).

The Pays de la Loire region has chosen the framework of an annual call for projects to finance 30% of the amount, excluding tax, of the work to redevelop the area around stations, which may include, among other things, the creation of a cycle route by the municipalities or EPCIs. For such a project to be eligible for the regional subsidy, the specifications state that the cycle route must link the centre of the town to the TER station over a maximum distance of 3 kilometres. This 3-kilometre limit avoids any windfall effect whereby a municipality or EPCI would receive subsidies for non-intermodal cycle routes.

As for the Grand Chalon, it grants subsidies to the intermodal cycling projects of municipalities on the basis of a "PDU label" for these projects.

Relationship of the AOM with the other AOMs in the catchment area

In order to guarantee the coherence of the intermodal bicycle- public transport offer at the level of a living area, it is necessary that policy coordination also takes place between the different AOMs in this living area. In this way, a user who moves from one urban transport perimeter to another, particularly for his daily home-to-work journeys, will be all the more encouraged to use bike-public transport intermodality as he will benefit from a fully integrated intermodal service: pricing, ticketing support, boarding rules, secure bike parking at the departure and/or arrival of the part of the journey made by public transport, types of bike rental service or LSV...

In reality, unfortunately, we rarely see such a degree of integration. At most, informal exchanges between technicians and elected officials of the different AOMs make it possible to obtain feedback on the solutions adopted by the different AOMs in the same catchment area. The region seems to have a coordinating role to play here. From this point of view, the Burgundy region has, for example, so far taken advantage of its consultation bodies between the AOTs of the territory to tackle the subject of intermodality, including the link between cycling and public transport. We should also remember the major role that will be played by future regional intermodality schemes, in which the "active modes" dimension will have to be fully mobilised.

2.3.1.2. The portage of bicycle & public transport intermodality

The technical and political support that cycling and public transit intermodality enjoys in a community is crucial to the success of the measures put in place.

First of all, the presence of an elected representative and a technician who are convinced of the interest of cycling in the development of an ambitious sustainable mobility policy is undeniably in favour of the deployment of bike-public transport intermodality. In Toulouse, for example, the development of this intermodality owes a great deal to the commitment of an elected representative of the city of Toulouse to cycling in the 1980s. Echoing him, the pro-bike convictions of a head of the city's "traffic and transport" department made it possible to spread a bicycle culture among technicians and elected officials. Thus, in each road and public transport project, the question of integrating bicycle facilities and parking spaces has been systematically raised. This approach was gradually reflected at the scale of the Greater Toulouse district, the forerunner of Toulouse Métropole, so that the arrival of the metro in 1993 was accompanied by the installation of bicycle racks around each station. In 2003, at the time of the extension of the metro line, the portage of the bike-transport intermodality was mature enough to allow the development of several secure bike parks with access using the ticketing support used in public transport. Conversely, replacing a team of elected officials on bicycles is likely to have a negative impact on the ambition of the intermodal policies implemented. In certain territories that have experienced such a weakening, we observe that the deployment of bike-public transport intermodality is stagnating, or even struggling to remain a priority in a context of increased budgetary constraints.

Furthermore, CEREMA survey shows that the place given to cycling by elected officials and local authority departments is growing, and that this issue is gradually taking on an intermodal dimension. In fact, according to the organization charts of the respondent community services presented on p. 56, the management of the bicycle file is now only in a minority of cases linked to the "roads" service, since less than 5% of the respondent communities choose this type of management, and is reaffirmed within the "active modes" services in one community out of five. At the same time, we observe the emergence of intermodal management of cycling: in nearly 40% of cases, the cycling issue is transferred to public transport services, while 3% of local authorities have introduced co-management between "road" and "public transport" services. In more than 25% of cases, the management of "bicycle" dossiers is even part of a "mobility and travel" service where all modes are considered as complementary. Taking into account these different intermodal management methods means that two thirds of the respondent local authorities have voluntarily chosen to manage cycling and public transport at the same time.

The increase in the consideration of the bicycle as a mode of transport in its own right can also be seen in terms of the increase in human resources devoted to it. In Toulouse Métropole, the departments alone have four technicians in charge of active modes and their intermodality with public transport.

As shown in the second graph on p. 56, a similar, albeit slower, trend seems to be taking shape in the political structure of these same authorities24. In more than 10% of cases, the bicycle issue is still attached to the elected representative in charge of roads, while only 12% of the responding local authorities have a specific "active modes" delegation responsible for dealing with cycling policies. Moreover, a political steering of bike-public transport intermodality is gradually taking shape, since in 52% of the respondent local authorities, cycling depends on the "public transport" delegation, while a fully intermodal "mobility and travel" delegation manages the cycling file in 11% of them.

It should be noted that in 6% of cases the political management of cycling is the result of a tandem between a "transport" or "mobility" elected official from the conurbation and a "roads" elected official from the city centre. Here again, in about two-thirds of cases, cycling and public transport are undeniably brought closer together.

Finally, it should be noted that this trend is not directly correlated with the size of the respondent communities, since each type of portage has very different sizes of communities. The local authorities that opt for an "active mode" delegation are as varied as the community of communes of the Pompey Basin, the Perpignan agglomeration and the Lyon metropolitan area. Similarly, a "travel" or "mobility" delegation has been set up in the Dieppe conurbation, the Reims conurbation and the urban community of Nancy.

2.3.2. Leverage of funding

Setting up a bicycle-group transport intermodality action can be very costly, particularly because of the diversity of expectations to be taken into account, which in turn is explained by the multiplicity of entities with expertise in this field25. For example, the initial cost of a secure bicycle shelter project is likely to be multiplied if the police authority expresses the wish to include a video surveillance system. This may force the community to reduce the project's ambition in terms of the number of shelters to be built. The consultation and financing choices made by the local authority responsible for a bicycle-transport intermodality project are therefore crucial.

On the one hand, solid financial partnerships must be set up, calibrated to the objective of intermodality. In this respect, European funds are an effective lever for initiating a bicycle/collective transport intermodality approach. In the Pays de la Loire region, these funds have been decisive in launching the multimodal information centre "Destineo", which brings together the region's public transport and travel services, the 5 departmental councils and 10 of the 14 AOMs in the region, and which has subsequently integrated "bicycle" journeys. The European contribution was made in particular within the framework of the European project ITISS26 financed under the INTERREG 3B programme. It totalled 350,000 euros, covering more than 20% of the project cost estimated at 1.7 million euros for the implementation and the first four years of operation of Destineo from 2005 to 200927. Similarly, the practice of co-financing and subsidising bike-transport intermodality by different levels of local authorities allows the implementation of ambitious actions. This is notably the approach adopted by the Centre-Val de Loire region to speed up the deployment of bicycle parking around stations, detailed above28. It should be noted that the removal, by the law on the new territorial organisation of the Republic ("NOTRE" law), of the general competence clause hitherto recognised to the regions and departments, does not call into question these possibilities of subsidisation. However, a region or department wishing to subsidise the action of another authority will no longer be able to justify this subsidy on the grounds of the local interest it represents for the citizens. It will have to link the payment of this subsidy to one of its own competences.

The second is to focus on maximising the impact of funding on practices. This can be achieved through a funding policy that is well limited in time and aims to stimulate a cycling dynamic. This is the case of Chambéry Métropole, which decided to subsidise the purchase of electrically assisted bicycles (EAB) by private individuals for three years to create a dynamic while avoiding any windfall effect. This strategy worked, since once the subsidy policy had been completed (750 applications processed), the dynamic of equipping households with EAB became self-sustaining. Similarly, Tour(s) Plus has succeeded in setting in motion a dynamic of equipping households with EAB by organizing an operation to distribute 130 bicycle vouchers per year between 2011 and 2014. The local authority now wishes to give priority to medium-term rental of EABs. Alternatively, the impact of financing on intermodal practices can be maximised by precisely defining the eligible users. Thus, the eligibility criteria set by the Pays de la Loire region for its subsidy for the purchase of folding bicycles target users who take their bicycles on board trains for their home-work journeys, since the subsidy is reserved for regular TER users (work subscribers and student-apprentices).

Rather than being perceived as a brake, the diversity of stakeholders to be mobilised in the context of a bike-transport intermodality project can therefore be seen as an opportunity to broaden the project's funding volume. In addition, multiple financial conditions can be imagined by local authorities to maximise the effectiveness of their funding on the progression of practices.

2.3.3. Land development priorities

The implementation of cycling infrastructure requires careful planning on the part of the community to ensure that it is used effectively.

In the case of bicycle parking lots, this implies an adapted dimensioning of the offer, a location in the immediate vicinity of public transport stops and ease of access. Consequently, it is essential that the local authority responsible for the intermodality project be in control of the land in order to be able to take account of this type of requirement. For example, on the territory of Toulouse, Tisséo-SMTC owns the land around most of the metro stations, which facilitates the development of bicycle parking in these strategic areas. As for the surroundings of the other metro stations, their ownership is the responsibility of Toulouse Métropole. In the latter case, the very close working relationship between Tisséo-SMTC and Toulouse Métropole favours the development of attractive bicycle parking facilities.

Nevertheless, in general, land control in the vicinity of public transport and in the stations is segmented between several owners. In addition, the land targeted for the installation of intermodal bicycle parking is often located in strategic locations, where there is very strong competition between the different possible uses (commercial space, car parking, bicycle parking, etc.).

The first challenge is to ensure that the bicycle plays a role in the trade-offs between these different functions so that it is one of the development priorities. Otherwise, the fact that the bicycle is not taken into account at the time of building a public transport station makes it difficult to deal with it later on. In particular, the initial planning choices may subsequently strongly constrain the development of an efficient supply of bicycle parking within the stations, in terms of volume and accessibility. The community may also be obliged to increase the number of signs to compensate for the lack of visibility of this offer.

A second issue for the community that does not own the land is the negotiation with the entities that control the land. It is a question of finding suitable arrangements (financing of investment and operations, project management, etc.) to ensure that the specific development requirements for cycling are taken into account, and thus create the most favourable conditions possible for intermodal practices.

It should be noted that land control around stations is very often the responsibility of SNCF Mobilités and SNCF Réseau (which brings together the former RFF, SNCF Infra and DCF entities) or municipalities. It is therefore the responsibility of local authorities with cycle-train intermodality projects to negotiate the terms of the operation with these players. For example, the "cyclo-block" programme in the Pays de la Loire region has mobilised the land owned by SNCF Gares et Connexions, SNCF Réseau, and municipalities to deploy bicycle parking facilities near stations. It was decided that SNCF Gares et Connexions would be the project owner and that the region would finance the entire operation. The land required for the operation was then made available by the project owner (for SNCF land), or was the subject of a tripartite region-contractor agreement between SNCF Gares et Connexions and SNCF Réseau (for SNCF Réseau land) or an agreement for the occupation of public land in the case of communal land. However, setting up bicycle parking operations on segmented land between several owners is not always easy, and the terms of the negotiation may prove unfavourable to the community instigating the project. In some territories, we observed that the implementation of a bicycle deposit was conditional on the community financing the landowner's move in addition to the payment of rent to the landowner. In other cases, the determination of the amount of rent paid by the community is approached at too late a stage in the development operation and cannot be effectively negotiated by the community, which tends to hinder initiatives.

2.3.4. Strengths and constraints of the territory and technical obstacles

The implementation of intermodal actions for collective bicycle-transport must not only be reconciled with the characteristics of the territory such as relief, density and heritage, but also deal with various technical constraints that can be costly to take into account.

2.3.4.1. The impact of the topography and density of the territory

Areas with a low relief and dense urbanisation have undeniable assets to promote cycling. They make it easier for local authorities to develop cycling facilities that are actually used, particularly in terms of intermodality with public transport. This favourable terrain can be found, for example, in Strasbourg.

On the other hand, local authorities with a high relief constraint and low density must demonstrate that cycling practices are possible on their territories before any action is taken in terms of bike-public transport intermodality. This is why some local authorities, such as Grand Chalon, are initially setting up a service for renting or making EAB available, or providing aid for the purchase of this type of bicycle. They can then make adjustments to their public transport offer to encourage intermodal practices in spite of the relief. For its part, Chambéry métropole has experimented with the boarding of bicycles on a bus line, equipped with a compartment suitable for storing three bicycles, to go up to the heights of Chambéry. This possibility was included in the internal regulations of the urban public transport operator after approval by the DREAL. However, this experiment was terminated after more than 5 years of operation, as the offer was not sufficiently attractive to intermodal users due to the operation of this line by "omnibus".

2.3.4.2. Technical constraining factors

Technical factors may also constrain the development of bike-pool transport intermodality in the territories. In terms of ticketing, for example, it is rare for local authorities to focus directly on the creation of a common ticketing medium for public transport and bicycle services, such as secure parking and self-service bicycles. More often, they face the challenge of developing interoperability between several pre-existing ticketing media, whose technical characteristics are very heterogeneous and the degree of technology varies according to the age of the ticket. This action is technically complex and therefore very costly, especially as it may involve replacing all the ticket validators previously used. It therefore forces some local authorities to keep two distinct media, to the detriment of the fluidity and ease of joint use of public transport and bicycle services. To a lesser extent, technical constraints may hinder the common graphic representation of public transport and bicycle network plans.

2.3.4.3. Taking into account landscape and heritage requirements

In addition, communities may also have landscape and heritage imperatives, particularly when their territory includes a listed historic centre. In addition to the "classic" consultation with the town planning department of the local authority concerned, they may have to take into account the opinion of the Architecte des Bâtiments de France (ABF) or UNESCO before carrying out intermodal cycle-transport facilities (cycle infrastructures, parking lots, etc.). The quality objective of intermodality must then be reconciled with the requirements of heritage conservation.

2.3.5. Relations with public transport operators and providers of UPT/ERW projects

This section shows that some public transport operators have a negative attitude towards cycling, which they may perceive as a competitor to public transport and not as a complement to it. One of the explanations put forward in the course of this section is the fear that cycling, whether on board or allowed on bus and tram lanes, may lead to a reduction in commercial speed and discomfort for passengers. They may therefore be reluctant to carry out intermodal actions, whether they relate to the boarding of bicycles or to the overall management of a mobility offer (public transport and bicycle and LSV rental or bicycle parking services).

To overcome this initial fear, some local authorities choose to draw up demanding specifications and undertake rigorous argumentation in favour of taking account of the bicycle in the operation of the public transport network. By way of illustration, Tour(s) plus entrusted the management of the conurbation's bicycle hire service to the delegate of the urban public transport service as of 2006 and imposed a combined fare that is very advantageous for subscribers to the urban transport network. It entrusted the transport delegate with the task of promoting the service and encouraged it to carry out a study of the impact of the service on public transport customers, which showed that many users were intermodal and that renting a bicycle did not imply abandoning public transport. During the construction of the streetcar, Tour(s) plus integrated secure bicycle parking right from the design phase of the project and entrusted the management of these shelters to the delegate. In order to convince its delegate - who was very reluctant - to accept the loading of bicycles onto the streetcar, the conurbation carried out a comparative analysis of the bicycle loading choices made by neighbouring conurbations.

It should be noted that local authorities are sometimes confronted at the same time with the lack of consideration of cycling by the project management or, where applicable, by the delegated project management of their exclusive right-of-way public transport projects. To deal with this, some local authorities include a clause in their specifications reminding them of the legal obligation to build cycle routes when renovating or creating urban roads (Article L. 228-2 of the Environment Code). This corresponds, for example, to the approach taken by the AOM Tourangelle, which has also ensured the implementation of this clause by getting heavily involved in demonstrating to its delegated project owner that the vast majority of cycle facilities were technically feasible and at a sustainable cost.

Conversely, good relations with the public transport operator significantly accelerate the deployment of intermodal practices. There is often a shared desire at regional level between the region and the TER operator to limit the number of bicycles on trains. This situation makes it possible to unite these two players around the development of intermodal parking services in the vicinity of stations: development of secure bicycle parking facilities, management and issuing of access badges by the TER operator's customer service department...

In addition, the operator of public transit networks, particularly urban ones, can develop a positive vision of cycling if it finds it worthwhile to engage in bicycle-transit intermodality. On the one hand, they can see this intermodality as a means of extending the area of influence of public transport and optimising its operation. In Nantes Métropole, for example, as we have seen previously, the rationalisation of the transport offer to improve its performance has been based on the organisation of cycle feeder services to the stops on the main lines. On the other hand, the fact that the operator manages some or all of the bicycle services present in the territory can be beneficial to its image in terms of sustainable development. This is the case of the operator of the Grand Chalon public transport network, which also manages, on the basis of a global public service delegation, the LSV and bicycle hire services. The operator perceives this mission in a positive light, since it represents a diversification of its service offer that enables it to position itself as more than just a carrier.

The involvement of operators in the development of cycling, initially or as a result of work to raise community awareness, is an important pillar in the construction of bicycle-transit intermodality. It can not only take the form of a boarding or parking service, but also make the intermodal offer more legible and easier to use: integrated management of bicycle and public transport services, one-stop shops, joint communication, joint ticketing support, combined pricing, etc. These elements are found in Nantes Métropole in particular. The management of the folding bicycle rental and secure bicycle parking services by Semitan, an urban public transport operator, has matured its vision of cycling and made the mobility offer more legible. Today, the operator communicates on these bicycle services and has a one-stop shop for the sale of public transport and bicycle passes. As for the operator of the urban network in the Toulouse conurbation, it has always seen the bicycle as a complement to public transport and has therefore worked very early on to improve their intermodality. This approach has made it possible to experiment with the boarding of bicycles on trams and the implementation of global communication.

On this last point, it should be noted in particular that in addition to the work carried out by Tisséo-SMTC, the commercial staff of Tisséo-EPIC is also working to raise awareness of the complementarity of the two modes, in the commercial agencies and directly on the network, in the exchange hubs when creating bicycle services. In addition, this favourable attitude towards cycling has probably contributed to the success of the Pastel common ticketing medium including bicycle services, and facilitated the full integration of bicycle data within the multimodal information centre (parking, intermodal route calculation, bike stations).

2.3.6. Communication as a promotional tool

Although nearly 50% of the local authorities surveyed by CEREMA consider bicycle/public transport intermodality to be an object of communication in its own right, the deployment of a comprehensive communication policy relating to this type of intermodality is still limited to a few territories. Indeed, in the majority of territories, the intermodality between cycling and public transport is only addressed in the context of general communication on cycling.

Although it is difficult to accurately assess the impact of communication actions on behavioural change, that local authorities consider them to be a factor in the appropriation of intermodal facilities and services and in encouraging the adoption of intermodal practices. Several types of communication actions can be distinguished and classified according to their duration, the specialisation of their message and the degree to which they target certain audiences.

We have chosen to include at the beginning of the following list actions implemented over the long term, disseminating any type of message relating to intermodality, aimed at any type of audience. Conversely, an action at the end of the list will be more like a one-off communication campaign, aimed at disseminating very specific information on intermodality to a well-targeted audience.

1. Dissemination of information on cycle/collective transport intermodality via the website and the information magazine of the community or operator. The information may be general (possibility of boarding bicycles on public transport, existence of intermodal pricing) or related to a particular current event (opening of a new intermodal bicycle parking area, etc.).

2. Awareness-raising carried out by the staff of the local authority or the operator in a dedicated reception area (mobility agency, sales agency, etc.) or on a stand at traditional events such as mobility week or the bicycle festival. This action can be combined with the distribution of communication leaflets. As in the previous case, the object of the communication can be of any kind.

3. Dissemination of intermodal information by e-mail or mail targeting certain users with an intermodal profile. In particular, Tisséo uses this communication to inform its users of the implementation of new intermodal bicycle facilities.

4. Posting on the public transport network and on advertising sites in public spaces, broadcasting of advertising spots. Tour(s) plus has thus used posters in public spaces to promote the Vélociti bicycle hire service during the work on the streetcar, and to publicise its fare, particularly in intermodal transport. A similar message has been put across in the form of advertising spots in the city's cinemas. Since 2012, communication on the intermodal offer has been provided by the operator, as part of the public service delegation.

5. On-site animation on the occasion of "intermodality" news. In Pays-de-la-Loire for example, this has taken the form of a leaflet deposit operation on "classic" bicycles on board trains, carried out by inspectors, to inform users of the regional scheme to help them buy folding bicycles. The region encourages users to choose folding bicycles rather than conventional bicycles when boarding trains.

These five modes of communication are complementary and make it possible to follow an overall communication plan on bicycle-transit intermodality.

By way of illustration, the organisation in Grenoble Alpes Métropole of three mobility agencies aimed at promoting any alternative mode to self-driving and their intermodality is a vector for a radical change in approach to mobility. In this respect, it emerges as a communication investment just as important as a highly targeted operation such as the one carried out by the Pays-de-la-Loire region on folding bicycles.

The operator of Tour(s) plus, which also manages the Vélociti bike hire service, has publicised Vélociti and its fares, particularly in terms of intermodality with public transport, by means of posters in the public area Credit: Website of the "Fil Bleu" public transport network of Tour(s) plus

Some local authorities manage to develop these multiple registers of communication on intermodality simultaneously. This is the case of Tisséo-SMTC and its management company, which provides intermodal communication on the website, both generalist and linked to a new bicycle- public transport intermodality offer, and operates selective communication by sending e-mails to certain users. The commercial agencies of the Tisséo network and the Maison de la mobilité (a structure piloted and managed by Tisséo- SMTC) are places for raising awareness of the intermodality offer, as are the animation stands at regular events (mobility week, etc.). Tisséo-EPIC's sales agents also organise occasional events at the transport hubs to promote new intermodal offers such as the opening of a new intermodal bicycle parking lot. Finally, Tisséo-SMTC uses poster campaigns on the public transport network (subway stations and trains, streetcar platforms, buses...) and in public spaces.

As for Chambéry métropole, it deploys "all modes" communication in order to ensure the coherence and complementarity of all modes. Its specificity lies in the fact that it relies in particular on the associative structure of the Ecomobility agency and the public transport operator. In this configuration, the staff of the agency and the operator are at the heart of a communication strategy that largely takes the form of bicycle-related activities and staff awareness campaigns. Once again, it should be remembered that communication will be all the more effective if it is based on the operators of public transport networks, so as to make intermodality more legible.

The Pays de la Loire region has carried out an operation to distribute leaflets on board TER trains, placed on the "classic" bicycles on board, to inform users of the regional scheme to help them buy folding bicycles. Source: Pays de la Loire Region website

2.3.7. Staggering the implementation of actions over time

Rather than immediately embarking on an ambitious approach to developing bicycle- public transport intermodality, some local authorities prefer to act in several stages. Some choose iterative experimentation approaches, enabling them to give greater robustness to an action before generalising it, while others rely on the study of actions implemented by neighbouring communities or communities with similar characteristics.

The experimentation approach, on intermodal services and facilities, makes it possible to test multiple actions, observe their impact on user practices and adjust them accordingly.

For example, Grand Chalon has simultaneously experimented with an LSV service and a long-term bicycle rental service. Today, the agglomeration community wishes to put an end to the LSV service, which appears less suited to the intermodality issues of a medium-sized agglomeration located in a large regional catchment area than a long-term bicycle rental service.

As explained in the first section, the Angers Loire Métropole conurbation has experimented with a secure individual bicycle parking service, which, in view of its success, has been extended to more remote residential areas of the conurbation where there is a strong demand for public transport. The conurbation now has around 150 bicycle boxes. These parking lots were deliberately designed to be light and mobile, so that the conurbation can regularly adjust their location based on an annual assessment of their use.

In addition, local authorities make extensive use of comparisons with the achievements of neighbouring communities before implementing an intermodal action. This method enables the local authority to adjust its action plan and limit the risk of failure. For example, the Picardie region conducted a comparative study of secure bicycle parking solutions in stations chosen by other local authorities, before setting up its own system.

2.3.8. Planning documents

It should be noted first of all that two-thirds of the responding communities have a mobility planning document, whether it is an urban travel plan or a comprehensive travel plan.

Even though intermodal actions can be implemented without a mobility planning document, the CEREMA survey shows that more and more AOMs are choosing to develop their planning document in terms of bicycle-transit intermodality.

Indeed, as shown in the graph on p. 73, less than 10% of the AOM respondents who said that they had such a document considered that bicycle/collective transport intermodality was not taken into account in it. It should be noted that all the AOMs that provided this response are in the process of preparing their first planning document, which suggests that intermodality has not yet emerged as a specific priority issue. In contrast, half of the responding AOMs feel that their document satisfactorily or to a great extent takes into account bicycle-group transport intermodality.

As an illustration, one can consider as a "pushed action", the one contained in the PDU of Tour(s) plus, which provides for the creation of a bicycle station with 600 to 1,000 places near Tours station. In addition, the PDU devotes one of its 14 orientations to intermodality (in particular with the bicycle) and refers to it in several of its other orientations. A transition seems to have begun since all the other respondents (43%) feel that this intermodality is taken into account at least marginally in their documents.

Nevertheless, the intermodality of cycling and public transport requires a period of acculturation in each community. Indeed, it is rare for this intermodality to be dealt with in the first version of a planning document. It is often a second stage that is supposed to boost the development of these modes of transport.

In this respect, the survey tells us that among the AOMs with several successive versions of their planning document, nearly 70% see an improvement in the handling of the issue over time, while the remaining 30% see stability and none of them show a deterioration in the handling of this issue.

In particular, it should be noted that there is a virtuous dynamic, according to which the more advanced an AOM is in taking into account bicycle- public transport intermodality in its planning document, the more likely it is to identify an improvement in this consideration compared to the previous version of its document. Thus, as illustrated by the graphs on p. 75, we check that: - 50% of the AOMs whose current document takes intermodality into account at the margin and which have a previous version report an improvement in the treatment of this subject, while 50% of them do not see any improvement. - Of the AOMs whose current document satisfactorily takes account of intermodality and which have a previous version, 70% report an improvement, while 30% report that it is stable; - As for the AOMs whose document is the most advanced and which have a previous version, all point to improvements in the treatment of intermodality in the various versions of the document.

In addition, the CEREMA survey results highlight a "generational" effect of travel plans. In fact, more than a quarter of the AOMs whose current document takes into account the issue of bicycle-public transport intermodality in a satisfactory or advanced manner do not have a previous version. This means that the attention paid to this issue has therefore been strong directly and has not experienced any intermediate stage. This argues in favour of a recent increase in the visibility of multimodality and intermodality issues, which implies that a MAA now embarking on a planning process should pay more spontaneous and sustained attention to them. It should also be noted that other factors may complement this analysis. In particular, the degree of political support can play a role in the extent to which bicycle-group transport intermodality is taken into account in planning documents.

In general, we note that a growing number of AOMs are addressing bicycle-supported transit intermodality in their mobility planning documents. The consideration of this subject has recently accelerated at the national level due to the maturity of a large number of AOM planning approaches, but also due to the generation effect of planning documents, which are now more naturally oriented towards the development of multimodality.

2.4. Conclusion

In view of France's hosting of the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) in December 2015, the territories are particularly keen to assert their central role in the fight against climate change. In the field of transport, the French transport organising authorities have many solutions to put forward, linked to the multiplication of policies in favour of multimodality and intermodality between alternative modes to "self-driving". The content of travel planning documents, particularly the AOMs, testifies to the growing importance of this approach.

AOTs has a central role in the development of intermodality between all modes. Rather than trying to do everything on their own, the various AOTs in the same area would benefit from coordinating and mobilising all the external skills relating to intermodality to a greater or lesser extent. Their role is also to find financial models to carry out an action with traditional partners, but also with a multitude of emerging players in the field of mobility (car-sharing structures, car-pooling players, insurance companies, mobile application developers, marketing specialists, car park and real estate managers, smart grids experts, etc.).

Among all the AOTs concerned, it is up to the region to guarantee the level of integration of mobilities in a territory and the overall meaning of the intermodality policy. The regional recommendations must then find an echo and coherence with the policies implemented locally by the AOMs.

The connection between cycling and public transport is an essential component of this intermodality system, which can be encouraged by the AOTs in a relatively economical manner in order to make these two modes more attractive.

The forms of policies in favour of this intermodality are evolving. On the one hand, actions aimed at intermodal "bicycle" infrastructure and bicycle hire, in whatever form, are now widespread and continue to grow. On the other hand, new registers of actions are emerging, even if the share of communities using them is still limited: combined pricing, common ticketing support, full integration of bicycles into multimodal information systems. The implementation of these measures requires, even more than for others, complex partnership action. They are essential if users are to adopt intermodal practices and make use of the facilities. In particular, comprehensive information is necessary so that users can take ownership of the intermodal offer and plan their journeys as well as possible.

In addition, more and more AOTs are introducing mechanisms to regulate the boarding of bicycles on public transport to facilitate intermodality, while ensuring a quality service for all passengers. However, there is no pre-established list of actions that would guarantee the development of intermodal bicycle-public transport practices. At the very most, we can stress that, in order to promote their development, it is essential to deploy an overall strategy linking several concomitant actions, and not to limit ourselves to an isolated measure such as, for example, the introduction of a self-service bicycle hire scheme. Intermodality policies take different forms depending on the size and density of the territories in which they are implemented. For example, measures may aim to connect modes in the urban fringes to reach the centre of the conurbation, to connect at stations to reach the whole of a catchment area, or to connect within dense spaces to improve travel in large urban centres.

The success of bike-transport intermodality in territories depends heavily on adapting the forms of public action to this issue. This subject must first of all be taken up politically and technically and have a fully-fledged place in the organisation chart of the AOTs via, for example, a dedicated delegation and a "transport and mobility" department.

Moreover, the construction of the overall intermodality strategy mentioned above potentially calls on levers of all kinds: cycling, transport, town planning, police, roads, land, communication, accessibility, data management, social cohesion, climate, air quality, heritage, safety, community life, economic development, parking, etc. No AOT is intended to control all these levers, even in the case of the AOMs, which nevertheless have a role in managing all forms of mobility. Moreover, the objective of connecting modes of transport almost systematically involves the action of several levels of local authorities. In this complex configuration of actors, the key to the implementation of intermodality lies in the ability of an AOT to carry out partnership projects with other local authorities and third-party actors involved in these fields of action (operators, associations, etc.), to ensure the development and operation of these services. It is easy to understand the importance of AOTs' coordination habits among themselves and with their partners. The ability of a TOA to position itself as a leader is crucial; it is up to it to mobilise skills and funding to serve the intermodality strategy, to demonstrate to transport operators the value of investing in cycling and to find contractual arrangements that adequately reflect this objective, and to convince citizens to prefer intermodal practices to self-drive. It should be noted that this observation has not been called into question by the legislative changes relating to the abolition of the general clause on the competence of the departments and regions.

In particular, we have noted that the role of the prefectures in the development of intermodal cycling and public transport was often linked to the promotion of tourism in a given area. It would therefore be appropriate to study the impact of the development of tourism intermodality on the progression of daily intermodal practices. Furthermore, cycling should be an integral part of the intermodality development strategy coordinated by the region and included in the Regional Intermodality Scheme (RIS). More broadly than the implementation of a "bicycle" infrastructure, the aim is to encourage the emergence of a real integrated intermodal service, compatible between AOTs in the same catchment area. This section has brought to light a few cases where regional action could foreshadow this situation. Finally, it is the responsibility of the region to ensure that this issue is reflected in the Schéma régional d'aménagement, de développement durable et d'égalité des territoires (SRADDET) into which the RIS will be integrated. The overhaul of the regional map and the partnership nature of the bicycle-transport intermodality actions highlighted during this section lead us to stress the need to build this plan in close collaboration with all the AOTs in the regional territory.

Chapter 3

Intermodal hubs for a sustainable city

Introduction

A hub is a place designed to improve intermodality. The term designates a spatial device that aims to physically bring modes of transport closer together to promote their (inter)connection or, when physical proximity is impossible, to arrange transfers to make them more legible and intuitive. Interchange hubs are therefore tools of intermodality, in the same way as multimodal information, pricing and coordination of transport supply on a network scale.

The exchange pole is above all the result of a development, of a deliberate intervention on the physical space in which correspondences must be organized. Creating intermodal pricing or improving timetable coordination is not enough to generate an interchange hub if there is no deliberate intervention to transform the space. This development action may have several purposes, but one of them, specific to the concept of interchange hubs, refers to the objective of improving the practice of intermodality.

Exchange hubs have gradually become part of the everyday language of public policy. While at the very beginning of the 2000s, documentation on transport hubs often referred to a dozen or so emblematic cases, in the space of a few years the evolution of urban transport networks, the development of urban public transport plans and intermodal policies have led to a proliferation of experiments and projects. On the one hand, on the "intensive" level, the major transport hubs have imposed themselves on political agendas because they concentrate major metropolitan issues and because they are the main witnesses to changes in networks, mobility practices and urban renewal logics. The example of the redevelopment of major French train stations (Paris Gare du Nord, Paris Saint-Lazare, Lyon Part-Dieu, Lille Flandres / Lille Europe, Rennes, Bordeaux, etc.) bears witness to this movement. On the other hand, on an "extensive" level, the notion of exchange hubs has spread widely throughout the territories, in planning documents as well as in concrete projects, particularly around the central stations of medium-sized towns and small cities.

This movement in the early 2000s was not unrelated to the fact that CERTU took up the subject at the same time by publishing various documents on transport and development policy tools: an annotated bibliography, which gave an initial overview of the already abundant literature on these tools (2002), followed by a more comprehensive work updating and enhancing academic and practical knowledge, and finally a series of summary sheets on development and partnerships between actors in these projects (2005-2008)[3]. In a context marked by the aspirations to promote sustainable land use planning, to associate spatial planning more closely with the evolution of transport networks, CERTU's involvement was aimed at supporting local actors to make the exchange hubs essential levers for sustainable development policies and control of automobile use.

Ten years later, while the challenges of global warming, air quality and social and geographical inequalities in relation to mobility issues have become considerably more pronounced, expectations around this complex issue are livelier than ever. However, because they are inherently partnership-based, transportation hub projects still suffer from fragmented interventions and public action in the areas of transportation, mobility and development.

How can a global vision of the object of the exchange pole emerge beyond the fragmentation generated by the heterogeneity of the networks that meet there, the different strategies or action logics involved?

From the most theoretical points of view to the most practical concerns, the question of the unity of the exchange pole arises in many facets:
- the unity in itself of the object "interchange pole" is not self-evident: "station", "bus station", "park and ride", "bicycle park", "car-sharing area" designate as many "modules" necessary for intermodality, which the expression "interchange pole" does not manage to homogenize;
- the unity of the project depends on the intersection of territorial strategies, a convergence of stakes and objectives at a given time. Even if the interests to be acted upon can be very diverse, the very essence of a hub is based on the convergence of public policies in order to define a common intermodal project;
- Unity of action concerns the management of projects of exchange hubs. First of all, a coordinated approach must be defined in partnership, and then the coherence of development choices must be maintained through appropriate governance, from preliminary studies to commissioning;
- the unit of place raises the question of the dimensioning of spaces and the morphology of the poles of exchanges. The place to be given to each of the modes and the equipment that accompany them must be assessed in an overall composition of the site, coherent in space and time;
- finally, the management unit for the exchange hubs focuses on the capacity to ensure the general smooth operation of intermodal locations. Their day-to-day operation is often put to the test by the diversity of partners, uses, operating times, individual expectations and capacities, etc.

These five reading axes of the unit of the pole of exchanges that are the units of object, project, action, place and management guide this contribution and allow to organize the five parts of this work. These parts are composed of a limited number of headings. Each of them deals with a specific issue, with a short development followed by recommendations for potential actors in the exchange poles. They are accompanied by bibliographical references for further reflection and a commented figure showing an example illustrating the section. In spite of this common framework, these sections nevertheless present a certain heterogeneity. In fact, they deal with knowledge that has been stabilized in various ways, experiences that offer a minimum of hindsight for some, or subjects that are sometimes more prospective. The choice has been made to highlight this diversity of points of view.

3.1. The hubs of exchange: what are we talking about?

The notion of "exchange hub" is now part of the lexicon of mobility players. Used to designate a project/place where modes of transport intersect, where urban design is made, where living spaces and services are deployed, it refers to diverse realities, functions and practices. Seeking to recall the contours of this object in order to facilitate a common understanding of it can be a prerequisite for action.

This first part returns to the elements of definition and characterization of the exchange hubs and intermodal mobility practices that they can provide, in order to propose possible recommendations for the owners of these complex objects.

3.1.1 Benchmarks on the terminology of the exchange hubs

The General Commission on Terminology and Neology (2007) proposes to define "hub" as "a point of embarkation or disembarkation of passengers or goods providing multiple connections between different transport companies in the same network or interconnection between different networks or modes of transport". The definition does not refer to the territorial depth of the notion of "hub" in geography and brings "hub" closer to other terms "used in this sense": "pivot", "platform", "hub", "exchange hub", "nodal point" (for rail) or "connecting platform" (for air). The foreign equivalent would be the "hub", even though in English the term "interchange station" is often used.

This official terminology is still quite ambiguous due to the use of very rich and confusing jargon. Other expressions have followed one after the other around correspondence, interconnection ("multi-mode correspondent", "interconnection pole"), exchange ("exchange centre" or "exchange district") or nodality (nodal point, nodal station, nodal space...).

However, this rich terminology converges towards the use of two expressions:
- the new "park-and-ride" system for connections between public transport and the car, instead of the "park and ride" or "park and ride" system, is designed to guarantee uniform road signs at the national and international levels with the acronym P+R (Park and ride; Parken und reisen; Parque et rouler);
- the term "pole of exchanges" operates a double semantic shift: the expression associates the term "pole" (as the centrality of circulations and the polarity of the territory) and the word "exchanges" (also having a social meaning). It is thus a notion that breaks away from the technical connotation conveyed by earlier expressions to designate the places, stations, and stations where intermodality between modes of transport is practiced.

Recent developments tend to use "interchange" as a generic term covering all situations of intermodality, not just between modes of public transport as initially implied. Park-and-ride facilities are therefore one of the possible components of a transport hub.

In order to detach the object of the transport hub from the strict dimension of public transport, the actors very often add "multimodal". While intermodality is the successive practice of different modes of transport during the same trip, multimodality is considered to be an alternative practice of different modes of transport for making one or more trips. The use of "multimodal interchange" thus suggests the idea of an intermodal arrangement involving different modes of transport, which is almost always the case.

Recommendation
Favour the use of "interchange hubs" as a generic term covering the diversity of facilities dedicated to intermodality.

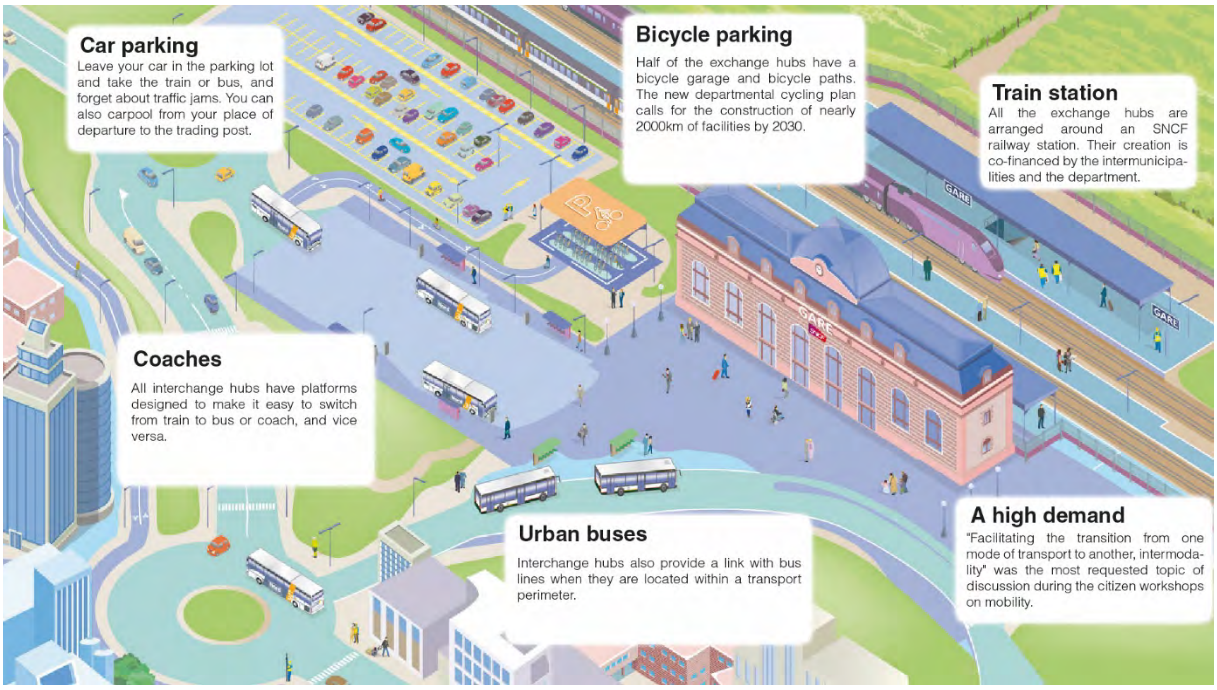


Figure 3.1.1. Diagram of a multimodal exchange hub

Source: Séguet, Le Nord, 2015

Note: This diagram represents the facilities of a "typical" exchange centre for the department of Nord. Between 2005 and 2015, as part of its responsibility for interurban transportation (now transferred to the Region), the Nord department participated in the development of thirteen intermodal transit hubs. Its participation in the financing can reach one-third of the total amount in the peri-urban hubs at the intersection of several bus lines.

3.1.2. Modes of transport involved

Several prospective analyses point to a shift between the transportation and mobility paradigms. One of the markers of this change is the significant diversification of transport modes through hybridization or cross-fertilization: the boundaries between public and private transport, between individual and collective transport, are no longer very clear. George Amar warns that modal diversity will continue to increase, referring to an optimal number of more than 20 or 30 "modes". It goes without saying that today all cities are "multimodal" and "multimobile".

Diversification of transport modes creates a greater need for intermodal connections, especially if the dominant use of the private car tends to decline. Each transport system needs a place, a transition zone between movement and stop. This interface between network and territory depends on the characteristics of the modes, for while a pedestrian or cyclist can stop almost anywhere, the TGV or airplane serves only a few places.

Mode of transport (network-service)	Type of network (network-support)	Point of contact between mode and network	Mode / network interface location
Walking, pedibus...	Street, road, sidewalk	Square, forecourt, sidewalk	Public space, waiting hall...
Bicycle, VLS	Road, lane / bike path	Roll bar, attachment, station	Bike park, Bicycle station
Individual car	Road, street	Parking space	Park & Ride (P+R)
Cab, VTC	Road, street, reserved lane	Reserved pitches	Cab Area
Carpooling	Route	Minute drop-off and pick-up	Carpooling area
Shared vehicle	Route	Parking space	Car Sharing Station
Coach	Route	Stopping point, station	Bus station
City bus, BHNS	Reserved or common lane	Bus stop / station	Bus hub
Subway, tramway...	Reserved lane guided mode	Station	Correspondence point...
Train	Dedicated rail track	Wharf, stopover	Railway station
Cable car	Cable transport	Station or station	Station or station
Plane	Air route	Terminal, terminal	Airport
River shuttle...	Seaway	Wharf, pier	Maritime station

Figure 3.1.2. Transportation modes and their networks, contact points, and interface locations

Source: Created by the author

The term interchange is more commonly used for connections between public transport systems, especially if there is a structuring rail mode. However, most of these stops, points, and nodes can be included under the term interchange if the place has an intermodal vocation. A park-and-ride facility, a bicycle station, a bus station, a carpooling area, can be considered as a particular component of a transport hub. Between all these nodes, walking is the common denominator of intermodality. It constitutes a mode of transport in its own right as a connector within these places of intermodality but also as a mode of feeder and distribution.

This book focuses on land modes of transport, thus excluding a more specific look at air and sea modes of transport.

Recommendations
Seek the widest possible integration of mobility offers, without forgetting walking, taking into account the type of urban environment, anticipate changes in the use of transport modes and the emergence of new intermodal needs.

3.1.3. Intermodal mobility: some benchmarks

It is generally difficult to obtain reliable and accurate data on intermodality, which is inherently complex to provide information: only the main mode of travel is generally identified or exploited through the classic "modal shares". General data can be obtained through local (CERTU standard) and national travel surveys that identify all the travel chains of daily mobility.

According to the national transport-travel survey (ENTD), the share of intermodal trips (i.e. one trip for one reason with several trips) averaged 2.3% on a weekday in 2008 for the whole of France (compared with 1.7% in 1994). Long-distance trips are more often "chained" with other modes of transport: 20.5% of long-distance trips are intermodal, generating 40.9% of the distances travelled according to the national survey.

At the city level, according to a sample of several household travel surveys (EMD) carried out in various French cities, intermodal travel accounts for 3.6% of daily mobility. Overall, this share varies between 1 and 10% depending on the provincial conurbations. Even if this use seems low, it is increasing quite significantly, particularly in the metropolitan areas. Moreover, the conventional measure of intermodality may seem partial since it excludes walking from the intermodal chain and counts trips rather than people. By considering people rather than trips and by including walking (from the five-minute walking threshold), 20% of people in urban mobility are "intermodal" on a daily basis (Rabaud, Richer, 2015).

Intermodality is an essential component of public transport. The modal share of urban public transport is the main determinant of intermodality in daily mobility (Richer, Rabaud, Lannoy, 2015). In Grenoble, public transport is present in 95% of intermodal trips (AURG, SMTC, 2016). Moreover, intermodal chains that do not include at least one mode of public transport are rarely considered. Ticketing data are therefore adapted to refine this important part of daily intermodality.

Even if the share of intermodal travel is low in some jurisdictions, this does not mean that there is not a strong case for addressing these practices. Indeed, intermodality often concerns longer than average trips oriented towards the centre of conurbations. This mobility, which partly relies on public transit, helps to limit car congestion in the centre and the associated environmental impact. Intermodality also raises issues of accessibility to the outskirts and the difficulty of travel on the outskirts of several transit authorities. As an example, the survey of major cell phone users in Picardy attests to the importance of intermodal flows to the Paris Region. The average daily travel time budget (3.5 hours) of Picardy residents who use the train to the Ile-de-France region (for an average daily distance of 165 km) generates situations of great hardship in daily mobility, aggravated by the lack of integrated season tickets.

Recommendations

Refine the knowledge of intermodal mobility by cross-referencing data (travel surveys, ticketing, counting, etc.);

Improve the knowledge of intermodal combinations by integrating walking as a mode in its own right;

Pay attention to the diversity of uses and users in the interchange hubs to avoid reducing expectations to those of a single typical user.

Intermodal people in the daily mobility of French cities

Through a sample of travel surveys, it has been measured that 7% of people (aged five years and over) have made at least one intermodal trip in their daily commute, i.e. by linking at least two mechanized modes for the same trip. In addition, 24% of people used at least two different modes of transportation during the day (people who made an intermodal trip by linking two different modes are counted with intermodal people).

If walking is included as a mode of transportation in its own right for trips of five minutes or more (about 400m or a bus stop in an urban area), the share of people who have made at least one intermodal trip in their daily commute climbs to 20%. While public policies have long pursued the objective of a strict modal shift from the car to public transportation, they are now more confronted with the issue of "rebalancing modes" in favour of multimodal mobility, in order to reduce exclusive car use (39% of people use only one mechanized mode, mostly the car).

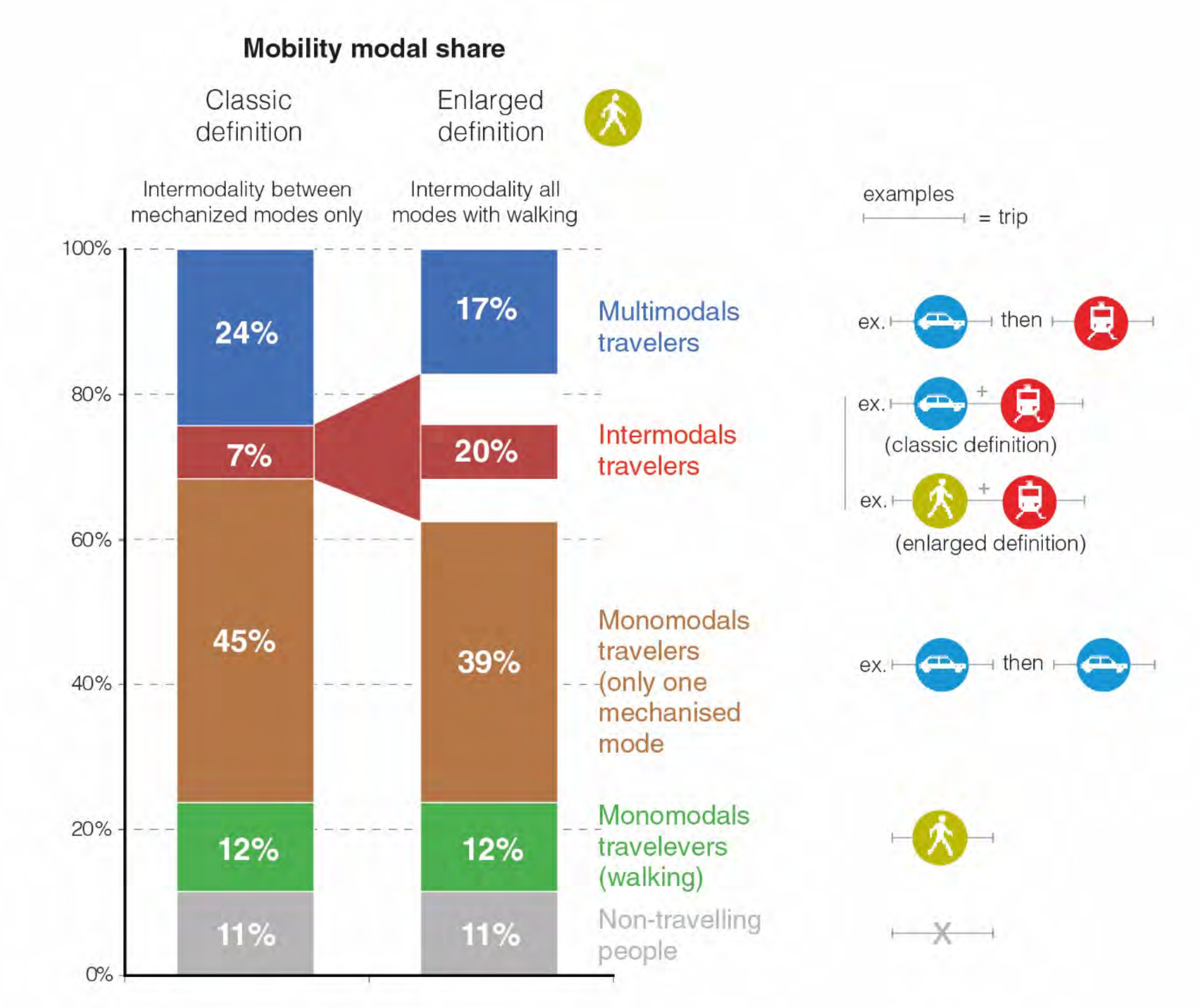


Figure 3.1.3. Typology of people according to the nature of their trips

Source: Rabaud et al., 2015

3.1.4. Correspondence: Reducing discomfort situations

While intermodality may seem to be a good tool for optimizing the various mobility offers (economic stake by being part of a structuring network), it can be a deterrent for users. In general, load disruption is a painful factor and can reduce the attractiveness of networks.

In transport economics, the utility function of transfer is negative. According to Wardman and Hine (2000), connections are all the more distressing:
- that they do not take place on the same platform, if you are old, loaded, handicapped, in a group or accompanied by children;
- the waiting time is long and uncertain and the waiting area is not hospitable;
- that you are not sure you will have a seat in the new vehicle.

The value placed on time by transit users (Litman, 2008) shows that time spent walking or waiting for a vehicle is perceived to be 2 to 5 times longer or more expensive than time spent on board. A transfer is usually estimated at a penalty of 5 to 15 minutes (in addition to the time objectively spent waiting). A user would therefore prefer a 40-minute direct trip to a 30-minute trip with a transfer.

The perceived "penalty" of correspondence can be reduced by improving the conditions of comfort and information. It also varies according to the quality of the modes of transport connected: a transfer between two infrequent buses is "more expensive" than protected and assured metro-subway connections, for which the penalty almost completely disappears. The uncertainty of the connection, the need to have a back-up solution and the environment of intermodal transfer partly explain these results. The difficulty of intermodal transfer would come from three different sources: the path to change modes, the waiting time, and the intermodal transfer environment (Zhan Guo, Wilson, 2011). These sources of difficulty require separate solutions, but they should not be carried out in isolation, as they all affect the same intermodal experience.

In large metropolises, the treatment of intermodality makes it possible to make load breaking less and less dissuasive. Indeed, the interest of the interchange is both to increase the complementarities between modes that offer very different transportation speeds and to make mobility offers that are diversifying more easily accessible in the same location. Thus, interchange hubs appear to be an appropriate response to the dual need to optimize the network and to limit (or cancel) the connection penalty.

Recommendations
Provide comfort and ease in situations that are inherently uncomfortable (and which may be even more so in the event of increased traffic or occasional or recurring disruptions);
Ensure that passengers in situations of connection or stress can find different ways to reassure themselves on their journeys.

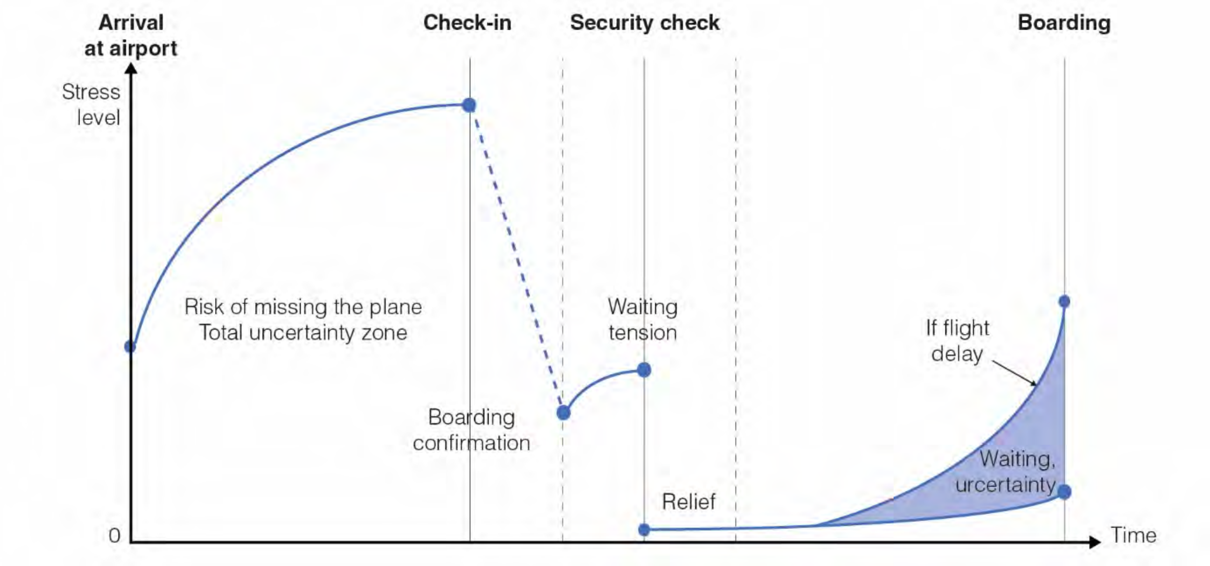


Figure 3.1.4. When waiting is stressful, the airport user example

Source: Aéroports de Paris, 2009

Note: Aéroports de Paris has conducted a study on the stress of departing passengers to better accompany connecting users in its airports. The "stress curve" drawn from this study shows peaks of anxiety in the uncertainty and waiting phases. The needs and expectations of each passenger are different and vary according to their instantaneous situation and location.

3.1.5. Functions and challenges of the hubs

Several generations of work on transport hubs - such as that carried out by the urban planning agencies of Nantes and Tours in the late 1990s - have referred to three major functions: a transport function, an urban function, and a service function. These three components do not have the same balance depending on the type of interchange hub, but this triptych appears to be a constituent part of intermodal locations:

- the transport function is the transport engineer's hub: how can intermodality and user flows be optimized? The challenge is to ensure a good connection between transport networks in order to secure intermodal traffic and make connections more reliable;
- the urban function corresponds to the architect's urban planner's exchange pole: how can we facilitate urban integration and design a neighbourhood focused on the mobility offer of the exchange pole? The challenge is to limit cuts, improve the legibility and integration of the exchange centre in its urban environment, and to maximize the potential for urban requalification on mutable rights-of-way;
- the service function corresponds to the exchange pole of the service manager: how to make places more functional and pleasant? The challenge here is focused on waiting, the stay in the exchange centre rather than on the flow. It is a question both of making the most of connecting times and of offering other attributes to the interchange beyond the transportation function (for example, services that make passengers' daily lives easier or complementary places of work).

These three functions are not free of paradoxes: between the penalizing side of the load break and the resources linked to the multiple connections; between the cuts linked to infrastructure and traffic and the strategic nature of urban organization around intermodal locations; between the feeling of losing time and the feeling of gaining time thanks to the services available.

	Positive aspect	Negative aspect	The stakes for the exchange hubs
Transport function	Resource place for diversified mobility solutions	Load breakage and hardship in the travel chain; lengthening and weakening of travel time	"Ease of switching from one mode to another"
Urban function	A strategic site for the reciprocal development of urban planning and public transport.	Urban cuts due to the concentration of infrastructure: traffic-related nuisances	"Making the city around the hubs of exchange"
Service function	Possibility to decorate and enhance the waiting time in a comfortable and safe place.	Feeling of lost time in spaces without basic comfort	"Make living spaces into hubs of exchange"

Figure 3.1.5. Pros and cons of intermodal hubs

Source: Created by the author

Recommendations
Apprehend all the facets of the pole to find a singular balance between the functions;
Collectively formulate the urban stakes of the hub;
Agree on the negative aspects that must be addressed.

3.1.6. The main figures of the hubs of exchange

The definition of the object of the exchange pole proposed in this work is not restrictive. It leaves open the possibility of using the term for a large number of facilities of very different sizes. Depending on the stakes and the institutions involved, one can find as many definitions as there are problems.

However, a few major figures for passenger land transport hubs can be described. Leaving aside airport, maritime, or river hubs (which refer to specific development and governance) and limiting themselves to inland passenger transport, the various figures of hubs can be grouped into four main categories, each of which includes several relatively homogeneous levels.

As every station has a vocation to become a hub, the first major figure concerns the hubs developed around a rail service. These are the most numerous projects for interchange hubs given the density of railway stations and stops in France (about 3,000). Historically, this heavy mode has called for connection with other networks.

At least three categories of rail interchange hubs can be distinguished by distinguishing for the first two the situation in or outside the Ile-de-France region:
- the hub of the central railway station, which hosts a national or even international service;
- the "regional railway station" interchange: in the Paris Region, these are the stations of the Transilien or RER networks, of varying sizes but with an average level of ridership without comparison with the regional stations in the provinces; outside the Paris Region;
- the 2,500 regional stations may be located in suburban areas, outside the territorial jurisdiction of an AOM;
- the few railway interchange hubs with specific locations, which are not "central stations" but which have a long-range service: These include stations built on new high-speed lines and/or near major facilities.

The second major figure relates to transit hubs built around a public transit road service. It is rather rare in France to find bus stations with regional, national or international services that are not linked to a railway station. However, these facilities are the focus of attention following the liberalization of domestic bus transport (the so-called Macron Law). On another scale, medium-sized cities with little or no rail service may be led to organize intermodality around a hub combining bus and coach services.

The third major figure concerns metropolitan scale transfer hubs that organize the network and the connection to urban public transit systems. These are generally urban-scale facilities, less visible and more functional than a central station interchange, but it is in these locations that intermodal mobility is most dense. There are two categories of interchange profile: hyper-central nodes at the intersection of heavy transportation systems that provide a link between different public transit lines. Because of their location and the priority given to urban public transportation, these hubs leave little room for the car. The other category concerns the organization of feeder services at the ends of the most efficient public transport lines. The arrangement of the car feeder is the subject of a specific variation with the term park-and-ride or park-and-ride (international acronym P+R).
The last type of hub, which is emerging today, is linked to the growth of shared mobility, whether or not it is linked to public transport. For example, car-sharing areas that allow a user to park his or her own car to become a passenger in another vehicle. Finally, it is the same principle as a park-and-ride facility, even if the vehicle subsequently borrowed is a private car and not public transit per se. Finally, we can also identify small mobility resource centres around meeting points for carpooling, car-sharing stations or bicycle services, possibly coupled with bus, coach or TOD services when they exist. It is therefore conceivable that the articulation of mobility offers in mobility hubs could involve communes of varying sizes.

Figure 3.1.6. Interchange hubs according to involved modes

Source: Created by the author

3.2. Exchange hubs: who are the stakeholders?

The pluralistic and complex nature of the exchange hubs is not only due to the diversity of the modes of transport they bring together. Indeed, behind this technical diversity lies a panoply of actors who maintain a singular link with the object of the exchange pole. These actors have skills, attributions, representations, and interests to act that they integrate to varying degrees and in varying time frames into a hub project.

Who are these actors? What role do they play in the emergence of a hub project and what interest do they have in entering the scene? What representations of the exchange pole object do they construct?

3.2.1. Panorama of the players in the exchange hubs

Because they represent meeting places for several modes of travel, the exchange hubs involve a wide range of actors. Public project owners, transport operators (rail, road, etc.), developers, lessors, planners, partners of the exchange hubs intervene by mobilizing skills, some of which have recently been reorganized. Indeed, since 2014, substantial changes have affected the distribution of skills between local authorities and the internal organization of the SNCF Group. At the same time, new players have emerged, contributing to the diversification and segmentation of the field of mobility.

First, with regard to local authorities, the institutional landscape of transportation organization in France has historically been structured (LOTI of 1982 and SRU law of 2000) around four levels of transit authority:
- the municipalities and their groupings, which are responsible for urban public transport;
- the department, competent in the field of non-urban transport;
- the Region, competent in matters of transport of regional interest;
- the State, competent in matters of transport of national interest.

With the law of August 7, 2015 on the new territorial organization of the Republic (NOTRE), Act III of the decentralization process redesigns the structure of local authorities' powers in the area of transport around three main organizing authorities (except in the Île-de-France region, where STIF is the sole organizing authority for urban transport):
- mobility organizing authorities (AOMs) can organize urban and non-urban transport, transport on demand and urban logistics within their territorial jurisdiction. Within the municipal block, they contribute to the development of new mobility services (self-service bicycles, car-sharing, car-pooling);
- the Region becomes the organizing authority for non-urban, regular or on-demand transport (apart from the organization of school transport for disabled pupils, which is the responsibility of the prefecture). It is also designated as the lead authority for the organization of intermodality. The new regions are piloting the SRADDETs (regional planning, sustainable development and regional equality schemes), one component of which deals with intermodality. It should be noted that decree no. 2016-1071 of August 3, 2016 relating to the SRADDET refers to "strategic exchange hubs";
- the State remains the organizing authority for rail transport of national interest.

Recent laws thus contribute to assert the role of the AOM/Region couple as the pivot of intermodal policies.

Local authorities are not only involved in mobility issues within the framework of their own competence: they are also mobilized in other ways by the exchange hub projects. Municipalities and their associations may act as owners of land on which interchange projects are being developed or as managers of roads and parking facilities. On a broader scale, inter-municipal cooperation structures in charge of planning (*Schéma de cohérence territorial*, SCoT) can also play a role through the identification of intermodal locations supporting urban planning and development.

As far as railways are concerned, the incumbent operator has also undergone a notable evolution. On January [1], 2015, the law of August 4, 2014 on railway reform created a large public establishment, SNCF, which includes two operational public establishments:
- the owner and manager of the SNCF Réseau infrastructure (which groups together the missions previously carried out by RFF, SNCF Infra and the Direction des Circulations ferroviaires);
- the incumbent transportation operator SNCF Mobilités, on which Gares & Connexions depends, which is responsible for managing passenger train stations and developing the services provided in these stations.

The railway reform did not lead to a simplification of the land parcelling of stations:
- Gares & Connexions owns the right-of-way for passenger buildings and forecourts;
- in particular, SNCF Réseau owns the infrastructure and assets related to infrastructure management (tracks, platforms, footbridges and underpasses).

Any project for an interchange hub backed by a railway station may therefore imply the presence of two distinct project owners if the operations concern the station itself (passenger building, forecourt, platforms, various railway installations, etc.). Note the special case of stations and stations in the Île-de-France region with properties that are shared between SNCF and RATP; the Grand Paris Express metro stations that will be created will be owned by the Société du Grand Paris and no longer by RATP.

In addition, since the railway reform, SNCF Immobilier was created within the EPIC SNCF to carry the strategy of land and real estate development of the group. SNCF Immobilier is therefore an essential interlocutor of the communities for projects of exchange hubs coupled with operations of development and real estate development on plots of land which are no longer useful for the functioning of the railway system.

SNCF and communities are also responsible for improving accessibility. For railway stations, SNCF is the leader on behalf of the State of the 160 stations of national interest, and the Regions (STIF in Île-de-France) of the 995 stations of regional interest. Accessibility master plans - Programmed Accessibility Agendas (SDA-Ad'AP) - enable them to schedule this accessibility work in order to comply with the law.

In addition to local authorities and the SNCF, the field of mobility is seeing the emergence of "new" players whose interactions with the hub object can be strong. The development of car-sharing services, self-service bicycles and car-sharing services is reshaping the landscape of the players involved in transport hubs and constitutes new or renewed uses to be integrated into such a project. Also, in terms of mobility, the recent law of August 6, 2015 for growth, activity and equal economic opportunity has led to the entry on the scene of new private players who can organize regular interurban road services with which the transport hubs must now deal. The development of these new services goes hand in hand with a reflection on the development of the bus stops and stations they serve. According to a statistical study by the FNTV, in 2012, 44% of bus stations were owned by a mobility authority, 37% by a prefecture, and the remainder by several local authorities or ad hoc structures.

Finally, a multitude of other players can play a role in the projects or operation of the transport hubs: car park, retail and service managers, developers, landlords and promoters are all players, skills and interests to be reconciled in the service of users.

Recommendations
To facilitate the scenes of cooperation between actors of the exchange poles at the service of the project;
Encourage the integration of new mobility players and define the terms and conditions of their participation in the governance of the exchange hubs.

3.2.2. The hubs of exchange in planning

Intermodality and exchange hubs have gradually made their way into planning documents. Expectations with regard to exchange hubs vary, however, depending on the types of documents, the territorial scales concerned, the dominant themes (urban planning, transport, climate, air quality, etc.) and the actors involved.

From their inception (1982), urban transport plans (PDU) have emphasized intermodal policies and projects for transport hubs. The vast majority of PDUs of different generations (LOTI, Air Act and SRU Act) have aimed to improve the linkage of public transport networks. The development of interchanges has often accompanied the construction of new transport lines (streetcars and other UPT/ERW), which these generations of urban transport plans have helped to promote. Park-and-ride facilities have also become increasingly present and urban transport plans have long placed great hopes in these developments (particularly with a view to controlling car traffic and developing public transport use) (Richer, 2007).

In the urban planning documents, the consideration of exchange poles is more partial and late. Following the SRU law, the SCoTs identified the challenge of urban planning/transportation coordination and the role that interchange hubs can play in urban structuring. The vast majority of SCoTs have identified as such privileged locations for urbanization, or "urban intensification", around public transport nodes.

At the communal or intermunicipal level, the PLUs include provisions that allow for the redevelopment of a station or interchange centre and its surroundings to be planned in different ways:

- by providing for the development of pedestrian walkways or bicycle paths to facilitate access to the hub in active modes;
- by preserving dedicated parking spaces in certain sectors;
- by providing for minimum densities to be respected around the pole;
- by enforcing standards for private and on-street parking to encourage the use of alternative modes of travel and limit the amount of space devoted to automobiles.

These project elements may be contained in the planning and programming guidelines or in the PLU regulations.

At the departmental level, the historical role of the county councils in the organization of interurban transport has long favoured a strong partnership with other actors. As such, and although situations vary, certain departmental travel plans or, as in the Nord department, a mobility plan, have been able to point to intermodality as a major issue. This positioning of the departments will therefore change following the recent transfer of the organization of interurban transport to the Regions in 2017.

At the regional level, the programming of the development of interchange hubs around TER stations has been present in the strategies of the regional councils since 2002. Some variations can be found, for example, in regional transport infrastructure (or service) plans (SRIT or SRT). In addition, some regions, such as the former Alsace region, have implemented specific development programs to upgrade stations. The intermodality component of the future regional plan for development, sustainable development and equality of territories (SRADDET), instituted by the NOTRe law, will be a tool for reaffirming the role of the regional level in transport hubs.

Intermodality planning at the regional level will then face the challenge of "multi-scale" coherence between the different planning exercises. Indeed, until now, the convergence of intermodal policies between different levels of government was not necessarily self-evident when trying to "put the plans back together". At the scale of the Lille metropolitan area, for example, the various planning documents testify to a profusion of interchange hubs: while a crossover study shows a number of major shared orientations, it also reveals weaknesses in the overall design of a coherent system of interchange hubs shared by all stakeholders (Dumas and Menerault, 2014).

Recommendations
To ensure coherence between intermodal policies implemented at different levels and by different institutions in terms of the development of trade hubs;
Identify the focal points for exchanges with particular issues in planning documents;
At the municipal level, use all the levers of the PLU to enable the development of the exchange centre and the neighbourhood in which it is located.

3.2.3. Typologies: what for?

On the scale of an agglomeration, a department, a region, the intervention on the poles of exchanges very often implies the establishment of a preliminary typology. Nature of the networks connected, geographical location, level of use, age and general condition of the installations, main expected functionalities... the diversity of the main characteristics of the exchange hubs in a given territory implies establishing categories that make it possible to find points of convergence and to give common reference points on the main principles of action envisaged.

There are many types of locally established exchange hubs and they mobilize a large number of criteria. While there is no "good" typology a priori, experience shows that a typology is relevant when it meets two key conditions: it must be built in a coherent manner with the desired principles of action, and it must remain relatively simple and appropriate.

While a typology of exchange hubs can enable an institution to explain the main principles of its policy in terms of intermodality, services, etc., not all typologies are intended to be carried out "in chambers". It may therefore be judicious to include the creation of a typology of exchange hubs (on the scale of a conurbation, a region, etc.) in a partnership dynamic, and thus make it a tool for dialogue between institutions. The elaboration of a PDU, or of strategic or planning documents at other scales, can offer an opportunity in this sense, and allow:
- to define a multimodal strategy in partnership, to be conducted on the different poles of exchanges of the territory;
- to build together the main categories of exchange hubs on the basis of simple criteria, which will enable this strategy and a program of actions to be implemented;
- to encourage the various partner institutions (all the organizing authorities, road managers, municipalities, the various components of the SNCF, etc.) to present and share their strategies and intervention priorities;
- to reconcile a territorial approach to transport hubs with an intermodal "transport" vision.

Recommendations
Explain the expected objectives of a typology... before attempting to accomplish them at all costs;
Make sure to mobilize contrasting but simple criteria and to make the pedagogical typology easily appropriable by the actors of the territory;
Make typology an instrument of partnership dialogue.

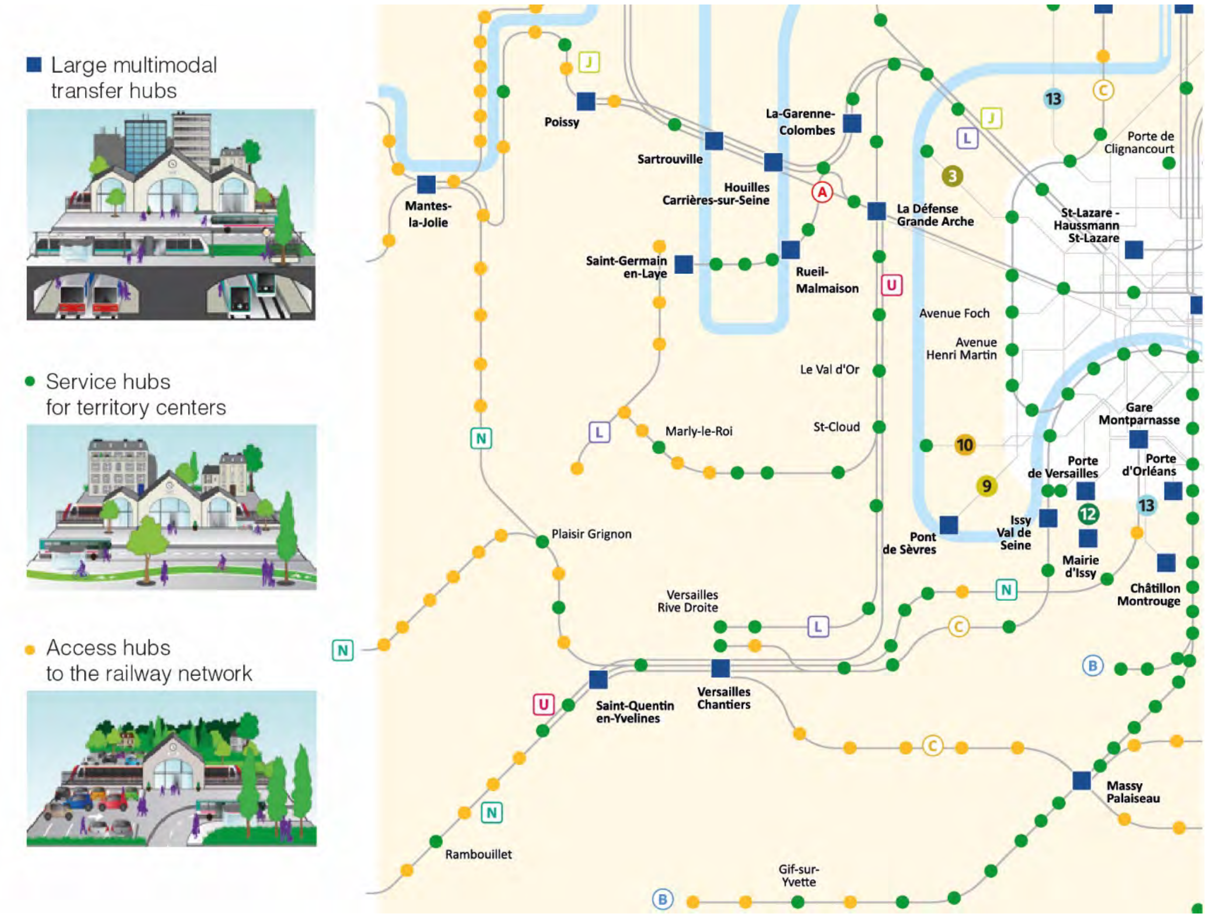


Figure 3.2.1. Multimodal transport hubs typology in Ile-de-France

Source: Île-de-France local transport plan, 2014

The Paris Region PDU approved in 2014 divides multimodal transport hubs into three categories:
- major transfer hubs: major nodes of the public transport network, they provide connections between the regional rail network and the surface networks that irrigate the regions;
- service hubs in the core areas: located on the network's structuring lines, they are made up of RER or metro stations located in dense areas in the heart of urban centres;
- hubs providing access to the rail network from the catchment areas: located in less dense areas of the region or on the bangs of central cities, access is therefore mainly by motorized modes (car, bus).

This typology, which is presented as a scalable one, then makes it possible to apply structuring principles in terms of the quality of service to be offered to users and the target developments that STIF is co-financing.

3.2.4. A variety of project triggers

The launch of a hub project is very often based on the convergence of triggering elements, the combination of which helps to set public action in motion. They contribute to the mobilization of different actors with a common interest to act. Several types of triggering elements can be distinguished: those linked to broader issues and those inherent to the site itself.

The emergence of a project for a hub of exchanges can be linked to projects that go beyond the site itself and reinforce its interest as a place of intermodality. The arrival of a new transport offer falls within this framework, with for example:
- the arrival of the TGV, the driving force behind the development or redevelopment of several generations of railway stations (for example, the current case of the Breton stations among others) ;
- the commissioning of a streetcar or exclusive right-of-way (e.g. Le Mans in 2007, Besançon in 2014).

These changes in the transport offer will generally result in increased attractiveness and therefore in forecasts of increased ridership, which will require improvements in capacity and the organization of intermodality. The transport hubs directly linked to the implementation of such projects will have to fit into their timetable. Indeed, the commissioning date of large-scale projects means that they will have to seek to reconcile deadlines.

At the scale of the site itself, the triggers can be of different natures. For example, at the scale of the site itself, the triggers can be of different types:
- a land opportunity can come to energize a more ambitious project. These opportunities have tended to increase since the reorganization of the railways, which are now more attentive to the development of their significant land holdings;
- a specific reflection on one of the site's facilities (creation or relocation of the bus station, development of a park and ride facility, requalification of the forecourt, etc.) may encourage the development of a more global approach;
- the project may arise from the desire to resolve a difficulty or a problem of under-capacity (for example, chronic saturation at rush hours, high demand for parking...), or to repair the consequences of an accident (the Limoges Intermodal Interchange Centre was built following the fire in the dome of the Limoges Benedictine station in 1998) ;
- the reaction to a serious safety problem (a pedestrian killed in Blois during a manoeuvre in the bus station) can motivate the triggering of reflections on the evolution of an entire site.

In addition, the role of private players in the emergence or development of mobility offers has increased: carpooling offers, recent liberalization of coach transport, and the new partnerships that the SNCF is developing with various operators. These developments are now generating new needs. It remains to be seen what interest public players have in participating in the development of bus stations or car-sharing areas as part of intermodal projects, even though the definition of the offer does not fall within their remit.

Recommendations
To keep this memory of the triggering elements, which prefigures the interplay of actors and the organization of the balances of governance;
Formalize the needs and issues that are at the origin of the project;
Beyond a sometimes-partial trigger with regard to the stakes of the exchange pole, seek to broaden and prioritize the other issues to be resolved.

3.2.5. Political support for trade hubs

At a time when the development of intermodal practices is a key objective of travel policies, transport hubs appear as markers of the choice of a certain voluntarism in public action. Because of the complexity of the projects and the obvious complexity of the partnerships involved, a strong political commitment is required to get all the partners involved moving. This political mobilization sometimes helps to ensure that the object of the hub is invested with a particular symbolic charge: thus, the affirmation of an ambition in the service of a conurbation, the demonstration of a region's identity and its capacity to influence, are often committed to its realization.

The idea of the "tertiary turbine", which had accompanied the first sketches of the Euralille project in the early 1990s, had seduced the elected officials of Lille, then struggling with an unprecedented de-industrialization of the territory. Two simple words summed up the hopes placed in the arrival of the North European TGV to halt this decline and bring about salutary economic development. More in the spotlight, the redevelopment of the Part-Dieu exchange hub, developed since 2014, if it aims to solve a real problem of under-capacity and urban integration, is a focal point for the renewal of the entire business district, which is very important for the influence of the Lyon metropolitan area. The redevelopment of the Chartres station hub, on which work is currently underway, also aims to strengthen the position of this medium-sized city in the Centre-Val-de-Loire Region, whereas until now it has mainly focused on the Parisian employment area. As for the future stations of Greater Paris, they will play an obvious role in building the identity of the future capital city.

Stations and trade hubs, at least for the largest among them, now seem to have an "insurance value" (Delage, 2013), which explains the political mobilization they are the object of as well as the economic hopes they can raise in a context of metropolitan competition.

However, even if the commitment of a local elected representative is a key to success, the creation of a hub requires a partnership-based sharing of expenses as well as functional, economic and symbolic benefits. The inauguration of an exchange centre is also an event where up to six or seven speeches follow one another: representatives of the town hall, the inter-municipality, the AOT (if different), the department, the Region, the SNCF and the State. Such an inaugural moment thus testifies to the various representations that the institutions in contention have of the pole of exchanges and which found their interests to act. A centre of exchanges can thus at the same time represent:

- the pivotal place for the reorganization of the territorial project of a commune for which the requalification of the centre requires the redevelopment of the station pole;
- the device allowing the action of an inter-municipality to be inscribed in space and to assert its influence;
- one of the key points of a regional planning policy aimed at better integrating stations and their surroundings into territorial action;
- a space of intermodality in which the SNCF's interests as a mobility operator are today condensed: the role of the station and its surroundings in the image that the group intends to give of itself, the challenge of positioning itself as an operator of mobility services that are not strictly rail-based (car rental, new mobility services present in several large regional stations);
- a composite state-owned complex that the SNCF - the land and property owner - is undertaking to develop through the implementation of services and shops (a very assertive strategy in major French stations) and through the transformation of railway land (the recent case of the new Rosa Parks station on the RER E suburban train line).

Recommendations
Explain the interests to act of each one to facilitate the convergence of the objectives of the exchange pole project;
To develop together a "mobilizing narrative" that makes it possible to bring the different registers of project justification into line with each other.

3.3. Exchange pole projects: how to do it?

The specific nature of transport hubs is due to the multiplicity of institutions involved: the city, inter-municipal authorities, organizing authorities at various levels, the SNCF, urban transport operators, in addition to developers, lessors, and sometimes a planner when the operations also include a real estate and urban component.

In essence, the projects of exchange hubs therefore have an affirmed partnership vocation. However, there can be major differences between institutions whose competences, territories, reference time horizons, constraints and financing methods differ greatly. Agreeing on common objectives and a coherent strategy, and maintaining this course in the course of a project during which hazards never fail to arise, is therefore a challenge.

This third part lists the main recommendations for the partners and project owners involved in these complex projects, in order to ensure the coherence of the hub from its conception to its completion.

3.3.1. Partnership commitments: the role of cluster protocols and contracts

An exchange pole project can involve up to ten institutions over a period of up to ten years. This process can be broken down into the following five phases:
- the emergence phase of the project;
- the study to define the cluster (program);
- design studies (preliminary project studies, project studies, execution studies, etc.);
- the realization of the works;
- reception and commissioning of equipment.

Because changes are inevitable over such a long period of time, and because it is important from the very first considerations to find a framework to gradually stabilize the process, formalizing the partnership is essential.

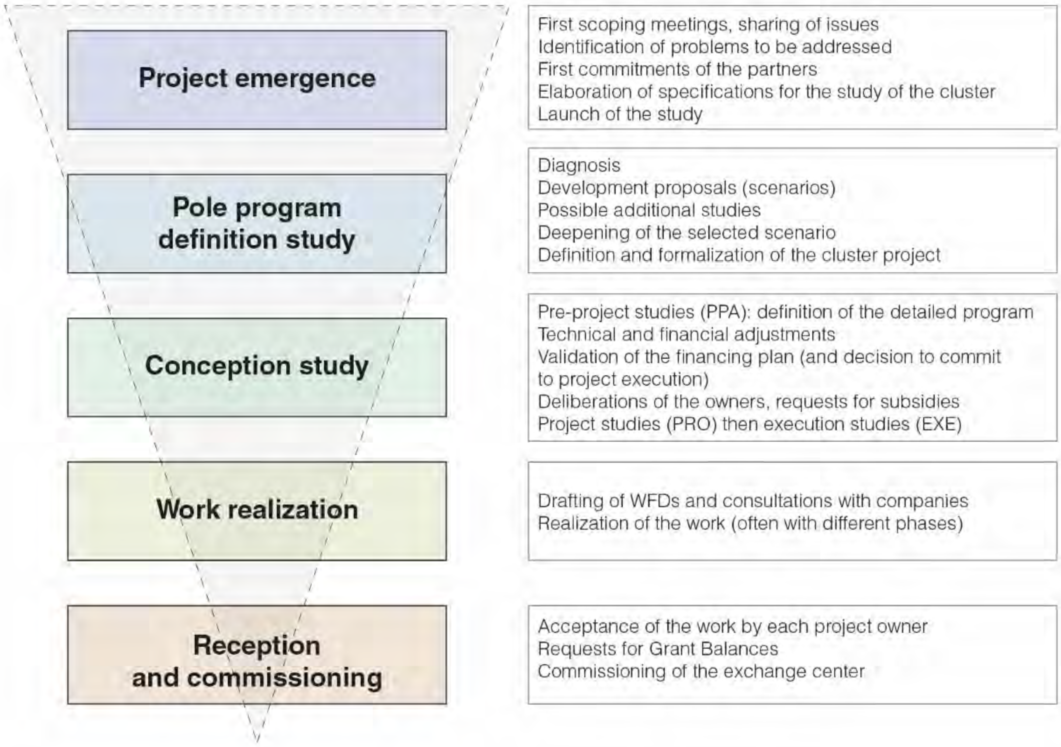


Figure 3.3.1. Exchange pole project different steps

Source: Created by the author

First of all, it seems essential that the commitment of all the partners to a common project be formalized from the upstream phase. This is, for example, what is recommended in the charter signed between the AMF, Gares & Connexions and Réseau ferré de France in 2011, which proposes that a "partnership governance protocol" be drawn up early in the process. Drawn up as soon as a project emerges, this protocol commits all stakeholders to a scope and schedule of studies, a working method and governance principles. It thus makes it possible to jointly define the main objectives of the exchange hub project and its major challenges, the different partners and their type of involvement, the steering bodies and the provisions relating to the overall management of the project.

It is just as important that the decisions taken at key stages are also formalized. Following the study phases (see the next two points), the chosen scenario and its financial package must be the subject of a document formalizing the partnership agreement. Indeed, a project of exchange pole implies several successive or simultaneous operations, and calls upon several types of financing according to the financiers and project owners involved. The provisional financial package, which indicates the estimated amount of the project, the estimated amount of the various operations that make it up and their respective financing methods, is essential for each of the partners involved to be able to launch the various steps (deliberation, grant applications, etc.) that will enable them to put in place the necessary financing.

Such a document is often referred to as a "partnership protocol", "cluster contract" or "scheme of principles". Ideally, it should cover the following four points: the program, the cost, the main deadlines and the financial commitments of each partner. It is also very important to show in this protocol the distinction between the scope of the study and the scope of the future project: the former, which is broader, provides a better understanding of the hub in its territorial and urban functioning.

Recommendations
Agree on governance principles in technical and steering committees;
From the outset, draw up and then validate a general memorandum of understanding (partners involved, major project objectives, scope, provisional study schedule, governance principles) with the steering committee;
At the end of the preliminary studies, draw up and validate a partnership document (such as a cluster contract) formalizing the resulting project set-up: program, cost, completion deadlines, provisional financial package, commitments of each partner.

3.3.2. Preliminary studies: jointly clarifying the field of constraints

The preliminary study phase plays an essential role in enabling collective knowledge of the development issues and the confrontation of the points of view of the institutions involved. To take into account the cluster's area of influence, it generally takes into account a wider perimeter than the future operational perimeter. It must lead to the elaboration of a shared development scenario, on the basis of which additional studies will then be launched.

While the project management of the cluster study is generally carried out by the local authority (commune or inter-community, depending on the case), it is essential that the specifications be drawn up jointly and that monitoring and steering be carried out in a concerted manner. STIF proposes, for example, that this study follow-up be conducted by a cluster committee created for this purpose. Initiating such a dynamic at a very early stage will encourage collective construction and ownership of the project by the various partners. To do this, the project owner of the cluster study can immediately organize an initial meeting in the field with all the stakeholders, and propose to gather and pool the various available study documents. Its role will also be to lead the writing of an initial collective formulation of the major objectives assigned to the preliminary study, and to steer the drafting of the study specifications.

Whatever the methodological breakdown of the preliminary study (in general: diagnosis, objectives, scenarios or variants, schematic diagram), its role is also to clarify the field of constraints and possibilities for the development of the cluster. These constraints usually relate to three aspects:
- a technical and functional aspect (functional organization of transport networks, connections, operating constraints, land and technical constraints of the site...);
- an administrative and legal aspect (identification of the contracting authority...);
- an economic and financial aspect (estimate of an envelope, financial arrangement).

The levels of depth of these studies are thus variable according to the difficulties that the project owners face in these three aspects. Depending on the case, proceeding by scenarios or by less contrasting variants makes it possible to agree on a common planning principle that is consensual and financially realistic for all the partners involved.

On the basis of the consensus scenario, the preliminary study may lead to the identification of the need for additional studies to refine the technical and economic feasibility of certain developments and variants, in order to make the provisional financial package more reliable and enable the various project owners to validate their commitment to the project. It is indeed essential that each planned expenditure has a meaning in the overall project, and that each financier has a clear vision of the expenditure allocated to it. These complementary studies can take various forms:
- Specific studies on the technical feasibility of structural operations or equipment (development of a bus station, construction of a new rail link crossing, PRM accessibility, redevelopment of a major crossroads, sizing and configuration of a parking lot, etc.);
- Opportunity and economic feasibility studies (e.g. conditions for changing a railway site, estimation of clean-up costs, comparison of various land control scenarios, economic simulation of the marketing of certain program hypotheses, etc.);
- technical investigations to be carried out to estimate the costs prior to certain works (presence of networks to be diverted, railway operating equipment, buildings to be demolished, etc.).

Additional studies must also allow an initial assessment of the operating costs of the structural equipment, as they may lead to the selection of a particular development solution. This subject is very important in the case of bus stations: the choices of spatial organization (location of stops, platforms, etc.) have effects on the manoeuvres imposed on buses or on the access routes to the hub, which can penalize operators and lead to accelerated deterioration of furniture or equipment.

Recommendations
Organize a joint visit to the site by all the players, including elected officials, for example during an initial steering committee meeting;
To pool as soon as possible all the study materials (diagnostics, counts, reference diagrams, etc.) available from each partner;
To define in a partnership way the specifications of the preliminary study, to explain the main objectives, to list the essential themes;
Identify the elements of technical or economic uncertainties in order to define the additional studies to be undertaken and their level of priority;
Associate current / future operators of the cluster (or some of its components) to specify the operating and maintenance constraints and assess future operating and management costs.

3.3.3. Articulation of the various project owners

A transit hub project is always based on the coordinated execution of various operations under separate project management: redevelopment of a forecourt, developments linked to the arrival of a streetcar or high-service bus, infrastructure works (underground car parks, for example), restructuring of the SNCF railway station buildings, creation of access paths for pedestrians and cyclists, relocation of the bus station, etc. The coordination of the contracting authorities is therefore essential, both for the design and assembly of the project and during the implementation phase.

Four forms of coordination are possible, two of which are provided for by Law No. 85-704 of July 12, 1985 on public project management and its relationship to private project management (MOP Law).

1) The scenario that largely prevails in projects is based on the free coordination of the various actors: through upstream consultation, a framework is collectively set that each party undertakes to respect in its operation. Each player retains his or her prerogatives as project owner, and each operation has its own project manager. It is therefore advisable to set up an operational committee, by appointing a common coordinator (who may be paid by each player).

2) A more efficient solution is the use of a project management agreement (article 2.II of the MOP law). This provision provides that several project owners designate one of them to act as project owner for an overall operation consisting of all the separate operations. This organization thus gives rise to a single project owner for a single overall operation, thus allowing the choice of a single project owner. It implies in return that this project owner insures the financial risk of the operation, and that the public persons concerned by the agreement lose part of their prerogatives. These consequences very often constitute a brake on its use. Used too rarely, the project management agreement nevertheless guarantees a high degree of consistency in the technical and architectural treatment of a hub project, which requires the coordination of numerous and complex operations to be carried out in concert.

3) A third possibility is sometimes evoked when it is an inappropriate solution: the "MOP" mandate for project management. This provision allows a project owner to act as agent for a second project owner (then called "principal") and to exercise part of its powers in its name and on its behalf. This tool is of very limited interest for coordinating operations with multiple project owners, in particular for procedural reasons and financial risk.

4) Finally, public procurement regulations allow different legal entities, public or private, to group their different orders for the award of their contracts into a single grouping of orders. The conditions of this grouping are fixed by agreement. A coordinator is designated to ensure this common order (the local authority for example). The advantage of this flexible and common provision is that it allows the choice of a single service provider, assistant to the contracting authority or project manager for example. It also offers the possibility of associating a private project owner, therefore not subject to the MOP law. The grouping of orders may provide for a single contract between the project owner and the coordinating project owner, or on the contrary, allow each of the project owners who are members of the grouping to make their own contract with the project owner selected by the coordinator.

The choice between these different possibilities must take into account, in each case, the expectations of the different project owners, their competence or technical experience and their willingness to relinquish some of their attributions or, on the contrary, to keep their prerogatives. Whatever the solution chosen, it is important that the different project owners ensure the coordination of their operations right up to the construction phase. It is indeed essential to be able to transform the interchange hubs while keeping them in operation, taking into account the constraints that arise in terms of network operation and the regulation of vehicle and passenger flows. To this end, if one opts for free coordination (first case above), the use of a scheduling, steering and coordination mission (OPC) is an essential contribution to the monitoring of deadlines and the coherence of interventions. Although this SPC mission cannot replace the overall project management function, it is an essential support mechanism for this function, which is decisive for the smooth running of operations and the future coherence of the clearinghouse.

Recommendations
Explore together the various possibilities of coordination, or even simplification of project management;
Use a master schedule for all project owners, regularly updated and shared, which allows to share the critical schedules and deadlines of each one;
Propose the choice of a scheduling, piloting and coordination mission (OPC) common to all project owners.

3.3.4. The overall coordination of the project in the design phase

To ensure the coherence of the exchange hub, project coordination is particularly crucial when moving on to the so-called detailed design phase. After the definition and partnership development of the exchange centre's program, this phase begins with the preliminary project studies (AVP). These studies define the detailed program of the various operations and the conditions for carrying out these operations before the works contract consultations are launched: architecture of the works, choice of materials, street furniture, operating mode, phasing and provisional planning of the works, operating and management methods for the works after acceptance of the works, detailed cost evaluation, etc.

This phase marks a particular evolution in the relationships between players, since a change of interlocutors often takes place: the teams in charge of the preliminary definition hand over to the operational project management teams (road, infrastructure and building services, etc.). It is as a result of this evolution that substantial inflections of the project can take place. Detailed design studies may lead to reconsideration of options taken during the preliminary studies of the previous phase. For example:
- new constraints, linked to technical standards, to the operating doctrines of the contracting authorities or to maintenance methods, can be integrated;
- certain roadway design choices made by the project management team can distort the spirit of the developments planned during the preliminary study phase (bicycle paths, pedestrian walkways, etc.);
- certain particular aspects of the project may not have been correctly identified or certain trade-offs made in the preliminary studies may not be sufficiently known to the project management teams.

The project manager has an essential role to play here for:
- ensure continuity and transparency of program arbitrations and adjustments made by the owners during the detailed design studies;
- Collect and share information on the evolution of execution schedules;
- optimize the overall project phasing;
- identify any additional studies to be undertaken;
- design a common communication device;
- to shed light on administrative procedures and their critical points (control of land ownership, validation stages of execution studies by project owners, etc.).

It is also important that the contracting authority retains direct responsibility for the evolution of the program, especially if the project management studies lead to new choices to be made.

Recommendations
Create, under the responsibility of the project leader, a coordination structure that allows at least the sharing of information between partners in the implementation phase (e.g. in the form of a monitoring committee);
Ensuring that the departments that managed the preliminary studies continue to be associated with the operational project management teams;
Maintain a strong political backing during this phase of project execution in order to arbitrate, if necessary, if changes imply revising the schedule, modifying the functional program, integrating new constraints, etc.

3.3.5. Consistency of architectural choices

Requalification of a station forecourt, redevelopment of access roads, development of the bus station, creation of a space or building dedicated to intermodality, installation of a park and ride facility, etc. Interchange hub projects involve several operations involving infrastructure, buildings, roads and public spaces, carried out by different project owners. Finally, the perception that future users will have of the hub (organization of space, unity, quality) will largely depend on the consistency of the choices made in terms of architecture, street furniture, flooring materials, lighting, landscaping, signage, waymarking and passenger information. All of these technical and architectural measures will help to unify the interchange and ensure the coherence of the various intermodal facilities.

Moving on to the project management phase involves a real risk of undermining the unitary approach to the site. The requirements of architectural unity and consistency of materials, and the need for rigorous work on soil continuity may be insufficiently understood by the project management teams of the various project owners.

The common choice of the same prime contractor, in the case of a single project management agreement, solves this problem of a global approach. But this choice is not always possible, or even desired by the partners in a project, who may wish to retain a certain autonomy in operational aspects, or to put forward specific know-how or requirements. The project management agreement can then provide for validation stages by each project owner before each decision by the main project owner.

When a hub project is designed and then carried out by separate project managers, the development of architectural charters, reference books or common specifications can guarantee the final coherence of the facilities. Documents of this type must be drawn up jointly so that each partner can appropriate them and refer to them afterwards. Their recommendations or prescriptions may include, for example
- on the types of materials to be used to guarantee the continuity of the soil treatment;
- on signage and staking (implantation principles, etc.) in order to have a homogeneous treatment of the exchange pole;
- on lighting devices, which must contribute to the ergonomics and legibility of the routes proposed to users;
- on street furniture.

Recommendations
If possible, choose a single project owner and then a single project manager for all the operations planned as part of the cluster project (which requires a project management agreement);
Otherwise, draw up a reference document (development charter, landscape charter, specifications book, etc.) that is common to the various project owners;
Organize specific coordination times for the project management teams, if necessary, by using a common coordinator.

3.3.6. Informing and mobilizing the public at the various stages of the project

Regular passengers, commuters, schoolchildren, more occasional passengers with connections, tourists, people with reduced mobility, users who are not seasoned public transit users, local residents or employees in the surrounding area who use the services or shops on site... the transit hubs are intended for a wide range of users. However, the weight of technical and organizational logic often leads to neglecting this diversity of the public concerned.

Beyond the diagnostics and surveys that can be carried out by the partners during cluster studies, involving the various audiences throughout the project helps to improve its relevance and promote its appropriation. Collaborative diagnostic approaches can, for example, shed additional light on the analyses carried out by institutional players. Later on, possible development scenarios can be the subject of a consultation process that goes well beyond the usual institutional partners, and which involves, for example, the future users of the cluster (shopkeepers, cabs, transport users, operators, local residents' associations, etc.) during dedicated round tables, focus groups or thematic workshops. More and more local authorities are now renewing traditional forms of consultation by adding to public meetings specific working sessions deliberately aimed at a very diverse audience, for example by mixing non-specialist citizens and representatives of associations more involved in technical matters, or by proposing exploratory walks on the sites.

The time required for consultation can save valuable time if it avoids late discovery of problems that might have been perceived and solved before. The gains of an enriched dialogue are also real for the dynamics of local democracy. Indeed, it offers citizens the opportunity to better understand the issues involved in developing the exchange centre, to question their own mobility behaviour, to perceive the diversity of conflicting interests around the project as well as the roles, resources and means of the various public or private players. The challenge is therefore to define the consultation strategy in partnership over the duration of the project's development, by explaining in advance what is covered by the regulatory obligations of each partner (the public inquiry, for example, depending on the type of work planned), and what the local authority wishes to carry out on a more voluntary basis.

In addition, communication to the public is paramount. A hub of exchanges is a complex object, subject to very strong logic and technical constraints, where institutional segmentation dominates. It is therefore essential to define together the way in which the scenarios to be discussed will be presented, the adjustments to be made once the project has been decided, and to oblige each of the institutions involved to translate the various operations planned or underway into simple, educational terms and visuals on common media. Particular attention must also be paid to the information that must be given on the works and their progress, and on the temporary measures that will ensure the operation of the centre throughout the duration of the construction site (possible modifications to access, parking, positioning of bus stops). For a hub to function coherently, it is essential that the institutions involved first and foremost communicate clearly and unified about the project.

Recommendations
Develop a communication plan common to all project owners and financiers for the duration of the project, and entrust its implementation to the responsible authority, inter-municipality or municipality;
Define a partnership strategy for consultation that is explicit about the possible obligations in this area, the expectations and objectives of the partners, who is responsible for the approach, and the mechanisms mobilized;
Solicit stakeholders specializing in consultation processes, and ensure that the public affected is diversified, in particular by making room for the "uninitiated" public alongside more institutionalized associations;
Appoint a site mediator present on the site of the work and available to inform residents and users and respond to the grievances expressed.

3.4. Exchange hubs: how should they be sized?

The dimensioning stage is essential to design exchange hubs that meet current needs and take into account the evolution of mobility over ten, fifteen or twenty years. On the one hand, it is a question of optimizing a valuable piece of land and managing the tension around the potential uses of the space. On the other hand, it is the choices made in terms of sizing that encourage, support and regulate future mobility practices around the transport hub. The trade-offs in terms of sizing reflect the idea of a certain type of intermodality operation that we wish to establish spatially. How can these trade-offs be made in the interest of users, taking into account changes in urban functions and intermodal practices?

3.4.1. Spatial coverage of the exchange hubs

A project for an exchange pole has first of all spatial characteristics and first of all a perimeter. In the project phase, the perimeter of the exchange pole depends on the limits of intervention of the various actors involved, the extent of land control and the nature of the operations. Projects where land control is important do not necessarily correspond to the largest exchange hubs. The existence of wasteland, abandoned land or mutable land that can give rise to real estate operations limits the constraints in the configuration of the exchange hubs. Beyond a highly variable land control according to the urban context, the operational delimitation of the exchange pole project rarely includes the spaces of use. This is why the project owners propose to distinguish a study perimeter (which corresponds to the area of influence) and an action perimeter (where the developments can be financed and implemented).

Beyond the surface area, the largest exchange hubs have a volume. Indeed, multi-level structures (parking lot, hall above the tracks...) and underground structures can coexist. The stacking of several levels is a factor of complexity for operations and for intermodal practices. In the densest urban areas and for interchange hubs with heavy modes, the multiplication of levels is unavoidable. However, it is important not to "abuse" the vertical deployment of interchange hubs, as was the case in the era of functionalist projects. Today, major developments tend to favour horizontal deployment of exchange hubs. Guided by new requirements in terms of universal accessibility, the horizontality of the interchange hubs facilitates the organization of pedestrian routes using flat paths.

While it is easy to determine the key places of a hub (the passenger building, the forecourt of a train station, the bus station lobby, etc.), specifying its spatial boundaries is often quite difficult. These must be treated more like membranes. Indeed, the risk is that the infrastructures and the induced traffic (railroad tracks, road tracks and hoppers, public transport dedicated sites, etc.) may cause cut-off effects that contribute to isolating the transport hub from its immediate environment. Certain large impassable plots of land or poorly integrated urban projects near intermodal transport sites can also create urban cuts that limit the transfer of the transport hub within its neighbourhood. Taking into account the membranes of the interchange hubs thus calls for work on a flexible, evolving and porous envelope to limit the effects of the edge, of which active modes (walking, cycling, etc.) are often the first victims. This link between the scale of operational intervention of the interchange and the scale of the district can be achieved through the local urban plan (PLU). The PLU can ensure the coherence of developments beyond the operational perimeter, and the possible articulation of operations in order to extend the effect of the transport hub in its direct environment, for example through continuous pathways.

Recommendations
Optimize the use of the land resource and control excessive consumption related to surface parking;
Limit the breaks between the exchange pole and its environment;
Slow down the surface networks so as not to hinder urban integration;
Seek as far as possible to flatten exchanges and favour as much as possible a "level" intermodality.

3.4.2. Trade hubs as points of articulation of transportation networks

The very existence of the exchange pole is due to the nature of the relations that this particular place maintains with other distant places. The articulation of different networks (rail networks, road links, public transport lines, bicycle paths or sidewalks...) is therefore essential, insofar as the characteristics of these transport networks define the quality of accessibility of the interchange hub (frequency, scale, capacity, cost...).

It is therefore necessary to take into account, when dimensioning the equipment, the current and future capacity of the networks entering and leaving the exchange hub (building a huge parking lot, for example, requires consideration of the access roads). Intervention on a particular network point also has an impact on the other places with which it is connected: for example, restricting access conditions to a park-and-ride facility can have immediate repercussions on the attractiveness of other parking lots on the same transport line.

It is important not to focus only on long-distance links and to also be concerned about the quality of the connections between the hub and the main central points accessible on foot or by bicycle. Proximity networks in active modes are rarely a source of attention, even though they are regularly the main means of access and dissemination of the transport hub.

For public transport that depends on a timetable logic, methods exist to measure the quality of connections. Indeed, it is not because the modes of transport physically meet in interchange hubs that their respective timetables provide "useful", reliable and efficient connections for users. Even if the timetable is not decided at the time of the interchange project, knowledge of the more or less good connecting conditions must be taken into account, if only to make waiting more pleasant if the connecting time cannot be reduced.

On a smaller scale, the challenge is to connect the different access points to the different modes of transportation in the most optimal way possible: bus stops, platforms, parking spaces, bike racks, drop-off points, etc. Walking generally plays the role of connector in the interchange hub, even though some major hubs or airports use treadmills given the distances to be covered. When the distances between two modes of transport in the same transport hub are large, the increasing use of multiple individual rolling objects (scooters, gyropods, etc.) could encourage designers to use tracks adapted to these practices while taking care not to hinder walking.

It is not always possible, or even desirable, to play on the physical distance of transfers to arrive at "dock to dock" type situations. However, it is important to seek to reduce the "cognitive distance". By making the correspondence as intuitive as possible, the load breaking situation can be made less disabling. The inconvenience of intermodality can be partly offset by services (information, guidance, pricing, etc.) or by the design of spaces (visibility, signage, treatment of gradients, limitation of unprotected crossings, more intuitive pedestrian paths, etc.). Finally, when trying to channel user flows so that they pass in front of shops, care must be taken to ensure that this does not hinder the fluidity and legibility of the connection.

Recommendations
To measure the current and future territorial accessibility of the hub in order to anticipate the needs for equipment and facilities, while not forgetting accessibility by active modes;
For public transportation modes, evaluate the quality of intermodal connections to improve the complementarity of transportation offers or suggest ways to improve waiting time;
Encourage the physical proximity of stops within a hub or, failing that, seek to reduce the cognitive distance and difficulty of connections.

3.4.3. A design that anticipates the evolution of flows and the urban context

There is no project without projection into the future. The dimensioning of an exchange centre is based on the anticipation of a twofold evolution in ten, fifteen or twenty years: the evolution of mobility, flows and movements on the one hand, and the evolution of the urban context, density and functions around the exchange centre on the other. This twofold evolution of the transport hub should guide the reflections on its dimensioning.

In order to envisage the evolution of mobility, we must first of all understand the current practices and possible dysfunctions. The first step is therefore to obtain quantitative and qualitative data on the uses of the exchange hub. The various actors involved in the project, particularly the organizing authorities and transport operators, have information that must be shared. However, it is often necessary to carry out specific surveys to obtain a comprehensive picture of the uses of the interchange (and not just of one mode of transport or another). For example, it should be borne in mind that not all users of the interchange are connecting, nor are they all users of the main modes of transport.

The first sketches of the dimensioning are generally based on the figures of the modal shares in decline: with which modes do we access the hub? At what times? From which locations? These initial projections of demand are often specified by counting and thematic surveys (car parking, pedestrian flows, buses, etc.). As the main consumer of surface area, car parking is generally a central and conflicting issue in the future design of transport hubs. It is always difficult to question the place of the car when demand is high. A more global reflection on the role of each mode of transport, as well as a projection on the urban evolution of the district, makes it possible to move beyond the sometimes-sterile debates on the number of parking spaces to be built. It is from these projections into the future that the place of the car in transport hubs should be determined, and not the other way around.

Knowing what the function of the exchange centre will be in the urban organization and the evolution of land needs in its neighbourhood is a determining factor in the dimensioning choices. This stage can be an opportunity to carry out a prospective partnership reflection on the evolution of networks, flows and urban projects on a large scale. These debates are generally found around major infrastructure projects that require anticipating territorial effects and changes in transport demand (for example, a high-speed line project). When the transport hub is not associated with a major project, elements of strategic thinking can be identified in planning schemes (PDUs present objectives in terms of modal shares over a ten-year period; SCoTs carry a planning project for the territory over a twenty-year horizon).

The objective of this step is to find a good spatial balance, avoiding two pitfalls:
- the risk of "suffocating" the interchange hub within a development that is too dense, which will limit the necessary adaptation of the hub to the evolution of traffic - often generated by urban evolution itself;
- the risk of over-consumption of space for transportation needs, which will force urbanization close to the transit hub and make it more difficult to integrate it into the urban environment.

The challenge for the players in the exchange hubs is therefore their ability to define forward-looking scenarios for the evolution of the offer and to preserve room for manoeuvre and capacity. It is not always possible to reserve room for manoeuvre, but it can respond to specific needs or rapid changes in supply:
- Some transportation hubs are faced with very "acute" traffic peaks that can be resolved by offering reversible solutions that avoid freezing part of the space for very specific needs;
- the rise of private players (long-distance buses, car-sharing, vehicles with drivers) is generating needs that are difficult to predict and are constantly being redefined; without room for manoeuvre, it is almost impossible to react to changes in traffic.

Recommendations
Share quantitative and qualitative data on the use of the hub and its neighbourhood, before considering more in-depth surveys on the grey areas;
Use knowledge of demand to build sizing scenarios that do not necessarily seek to amplify the initial trend but rather to rebalance uses from a multimodal perspective;
Don't build too close to the pole, plan for mutable spaces that allow the PEM to evolve;
To lead a prospective partnership reflection on the evolution of networks, flows, urban projects and the road network.

3.4.4. The principles of localization and mode prioritization

The exchange hub is made up of a multitude of "modules" or intermodality equipment specific to uses or modes (bus station, bus station, bicycle station, car parking, drop-off/drop-off, etc.). The objective of the interchange hubs is to seek overall synergy within a coherent development to facilitate intermodal practices according to a principle of mode hierarchy. The choices in terms of hierarchy will vary according to three main criteria:
- the type of urban environment and the allocation of land in the local urban plan;
- the position and role of the transport hub in transport networks (function of drawing down a large, diffuse area, function of serving a district in a dense urban environment, etc.);
- the local stakes of the operation of flows within the perimeter of the exchange pole (location of the main roads, preferential links to centralities...).

Even if the exchange hubs always take place in different contexts, a generic principle can guide thinking in many cases: it is based on the idea that motorized modes must be positioned on the bangs of the exchange hub. It is a matter of "filtering", as it were, all the modes that connect to the interchange in order to make users pedestrians.

At the heart of intermodal exchanges is the walk, which concerns all the uses of the exchange hub. The importance of walking (and PRM travel aids) is reinforced by the requirements of universal accessibility in transportation facilities. As an extension of this, it is increasingly common to find "augmented walkers" making intermodal transfers using folding bicycles and related objects, scooters and skates, whose uses must be thought out and coordinated with the overall operation of the transport hub (in terms of safety, for example). At the entrance to certain zones (station building, platform, etc.), floor coverings or markings may indicate a ban on the use of rolling stock.

Bicycle parking is a major concern given their intermodal potential and the limitations of boarding solutions. The choice of the location of equipment - from simple hoops to larger "bicycle stations" (covered and secure spaces dedicated to bicycle storage and with services) - is strategic: taking care to limit conflicts with pedestrian flows, it is important that bicycle parking be located on a direct trajectory between the accesses to the interchange and the destination once the bicycle is parked. This is why it makes sense to distribute the facilities at the various access points to avoid long detours for cyclists.

Depending on their nature and frequency, public transport stops may be located on the edge of pedestrian squares. Some modes, such as modern streetcars, coexist more easily in a pedestrian environment than buses, which are more difficult to erase. Location principles must meet the need for visibility in order to limit the difficulties of locating a transfer. Bus stations are rarely perceived as value-adding facilities: most of them do not have a particular heritage or architectural quality. Even more than for urban buses, coach traffic must take into account potential conflicts of use and cut-off effects. For reasons of safety, size and type of vehicles, or stopping times, bus stops or stations must be judiciously positioned in the interchange: if the bus station is not the structuring mode of the interchange, it is necessary not to let this equipment invade the pedestrian square, to avoid the accumulation of heavy infrastructure in a reduced space.

Automotive drop-off and pick-up equipment is not always well anticipated in the hubs. We are talking here about "accompanying" vehicles other than CT, in other words access to the interchange as a passenger in a car. This car, which can be driven by a cab driver, a VTC driver, an "institutional" car-pooler (connected by a car-pooling site) or a "personal" car-pooler (colleague, family, friends), does not require long parking in the interchange. Several distinctions can be made: cabs can have access to an area reserved for picking up their passengers in an advantageous position in front of the main entrance. Dropping off and picking up do not give rise to the same needs and stopping times, which makes pooling more complex. For certain hubs subject to mass departures and returns, it is preferable to separate drop-off and pick-up.

With a view to regulating individual car use, care must be taken to ensure that car parking does not take up the most advantageous locations. However, there is not one but several car parks, linked to the diversity of uses or users: in addition to the GIC-GIG reserved spaces, there are reserved spaces for CT subscribers (more or less long term), for electric vehicles, for the different forms of car sharing, for car pool cars to which can be added spaces for the different services, for hire companies, for deliveries or for SNCF agents. Hence the questions about location: should one single "pocket" of shared parking be used or several? How far can we go in the segmentation of car use? All these questions almost systematically argue in favour of intelligent parking control, in particular to reserve parking for users who really need it. In Geneva, for example, park-and-ride subscriptions are accessible under conditions of eligibility (CERTU, 2013).

Beyond the organization of parking on the scale of the interchange, the definition of a parking policy on the scale of the neighbourhood, the municipality and the public transit line is necessary. Consistency with parking beyond the interchange avoids undesirable effects such as the transfer of motorists to the neighbourhood parking lot or to another stopping point.

Equipment	**Maximum recommended distance**
Bike parking	70 meters from an access to the passenger building or the docks
Bus station	75 meters from the access to the railway platforms
Farthest car parking space	300 meters from the passenger building
Definition of a parking policy	Radius of 500 meters around the station

Figure 3.4.1. Hierarchical location of adjacent access equipment recommendations

Source: STIF, 2015

Recommendations

Prioritize the operation as the central element of the exchange pole and as the "connector" mode of the different equipment;

Prioritize, according to the exchange hubs, the modes of access: first the active modes around the structuring mode(s), then the drop-off/return and other public transport, and finally the parked individual car;

Make the parking offer at the transit hub consistent at the neighbourhood or municipal level and at the transit line level.

3.4.5. Benchmarks in the dimensioning of intermodality

The development of exchange hubs is a form of management of the scarcity of space where traffic flows converge. The dimensioning of interior spaces and platforms refers to precise standards: fire safety regulations or accessibility regulations relating to ERPs. The sizing of interior equipment is linked to the level of comfort desired (passenger density and throughput) within the limits of safety thresholds (public evacuation time).

Without detailing all the regulations, let's just recall a few provisions relating to the decree of December 24, 2007 approving safety rules against the risks of fire and panic in stations:
- a location where the public parks and transits must have at least two clearances. Where the number of members of the public is greater than 200, each normal clearance at such a location shall be at least 1.40 metres in length;
- the dimensioning of these clearances is defined according to the theoretical size of the public called upon to use them, the speed of traffic and the flow rates [...] in such a way that the evacuation of the public to a non-disaster area is completed in less than 10 minutes;
- The flow rate can vary from 120 passengers per minute for an escalator in operation to 30 or less for an escalator at rest or for tripod passages;
- The pedestrian speeds taken into account for the flow calculations are as follows: 1m/s and stepped 0,40m/s.

For outdoor spaces, we can indicate a few benchmarks in terms of the land right-of-way according to the various facilities. It should be noted that this is only a functional estimate of the spatial dimensioning which does not take into account the ancillary needs in terms of operation, services or maintenance of a hub.

	Approximate space required (m²/space)	**Comments**
Car parking	25 m²/square meter (2.5 m wide, 5 m long, 5 m clearance) 33 m²/square meter PMR (3.3 m wide)	P+R on surface = minimum 50 places (below that, look for solutions on the road) P+R in work = minimum 300 places
Deposit & Pick-up (cab, VTC, carpooling)	30 m² per cab parking space (with access and maneuvering) However, dedicated facilities with reserved access, to guarantee greater fluidity, may include 50 to 100 m² per square.	Each drop-off location has at least 3 places.
Bike parking	1.5 m²/place (normal arch) and 1 m²/place (double level rack) (Héran, 2008). For a comfort of use, the Guide ProVélo Suisse (2013) counts 2 to 3 m²/bike.	Bicycle shelters = minimum capacity of 20 places per access to the station. Collective lockers = minimum capacity of 30 places
Motorcycle parking	4 m²/seat)	To differentiate from bicycle parking
Bus hub	100 m²/ stop to 150 m²/ stop (for articulated bus 25 m) in roadway therefore without reserved access; 250-300 m²/ place with reserved acces	Propose a berth sizing of approximately 10% to 20% higher than the strict need
Bus station	125 to 400 m²/place for 13 m or 18 m coaches, not including possible regulation zones. The ratios tend to be more like 400 m²/place and even much more when the accesses are reserved (1000 m²/place for large bus stations).	In Île-de-France, a bus station is considered a bus station when the equipment has a minimum of 5 berths on a dedicated off-road right-of-way.
Pedestrian square	Depending on the level of comfort you wish to achieve (figure). This surface cost applies to all users, those who come on foot but also to all others.	Accessible PMR pathway with a recommended width of 2 m (N.B.: some architects of large projects talk about a width of more than 3,50m

Figure 3.4.2. Benchmarks of land consumption for the equipment of a trading centre

Source: CETUR, 1992; Héran, 2008; STIF, 2015

Some ratios (table):
150 m² = one cab rank = 4 reserved parking spaces for PRMs = parking for 35 motorized two-wheelers = parking for 100 bicycles
500 m² = one-minute drop-off and pick-up (8 to 10 places) = one 250-seat bicycle station
2500 m² = 6 to 8 platforms of a bus station = 100 parking places

For smaller transit hubs, the sharing of equipment can be a solution (for example, the passenger waiting shelter can be attached to the bicycle shelter). However, the greater the flows, the more equipment must be segmented: for example, more immediate drop-off must be dissociated from pick-up, which requires a longer waiting time; similarly, parking areas can be differentiated according to duration.

Recommendations

The dimensioning of intermodal equipment must take into account the large differences in land consumption and the concern to optimize space;

Beyond the consumption in terms of space, it is also the yield in terms of space-time that must be evaluated ("cost" per user in m²/hour of occupation);

Include a prospective dimension in this approach, taking into account traffic projections and programmed urban developments.

Level of service of pedestrian spaces in interchange hubs

The North American Transit Capacity and Quality of Service Manual, which is regularly updated and available for free download, provides interesting benchmarks for transportation system capacity and service quality levels.

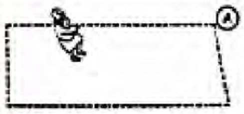
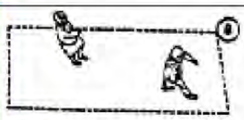
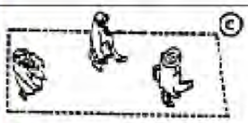
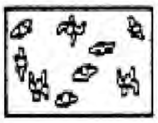
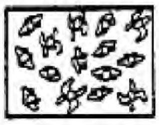
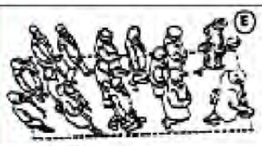
LOS	Traffic	Density (m²/person)	Flow (person/m/min)	Parking	Density (m²/person)	Average distance between people (m)
A		>3,3	<23		>1,2	>1,2 m
B		2,3 to 3,3	23 to 33		0,9 to 1,2	1,1 to 1,2
C		1,4 to 2,3	33 to 50		0,7 to 0,9	0,9 to 1,1
D		0,9 to 1,4	50 à 65		0,3 to 0,7	0,6 o 0,9
E		0,5 to 0,9	65 to 80		0,2 à 0,3	< 0,6
F		< 0,5	> 80		< 0,2	variable

Figure 3.4.3. Level of service of pedestrian spaces (traffic and parking) in interchange areas

Source: Transit Capacity and Quality of Service Manual, Third Edition

Its tenth chapter is devoted to the dimensioning of stations, stations and interchange hubs. It is essentially based on the ratios established in the 1970s by J.J. Fruin on the sizing of pedestrian facilities. These ratios relate, for spaces devoted to waiting or traffic, the occupancy densities, the corresponding flow rates and the average distances between people. They are broken down into six levels according to the comfort that one wishes to offer to pedestrians.

3.4.6. Towards the universal accessibility of exchange hubs?

Since the French law on accessibility of February 11, 2005, extended in 2014 by the ordinance establishing the programmed accessibility agendas, all developments must take into account the different situations of disability and reduced mobility. Exchange hubs, at the crossroads of multiple problems in user routes, are no exception to the rule. Accessibility obligations can be seen as both a requirement and an opportunity, which contribute to the conception of transport hubs as places that reinforce the autonomy of all types of public.

Universal accessibility appears to be an objective to be achieved in the projects of exchange clusters. The principle of universal accessibility is aimed at all people with disabilities (motor, mental, psychic, sensory) and must be applied right from the design stage of a project or service. Thinking in terms of "universal accessibility" for exchange hubs is a challenge that is all the more ambitious since the disruption associated with intermodality very often generates stress.

For successful accessibility, this issue must be integrated as far upstream as possible in the development process and as part of an overall approach, in order to ensure the continuity of the travel chain, which includes the built environment, transportation, roads and public spaces. This is the challenge that must be met by projects for transport hubs at the interface of these three areas, often managed by different players:
- the exchange hubs are generally made up of one or more establishments receiving the public (ERP) such as the station passenger building, the metro station, the park and ride facility, commercial agencies, etc. These buildings, which may have different owners (SNCF, RATP, AOM, local authorities, etc.), must be accessible to people with reduced mobility (if they are not already accessible) within the deadlines specified in the programmed accessibility agendas (Ad'AP);
- accessibility to rolling stock and to the various modes of transportation (passenger areas, platforms and their accesses) is all the more complex in interchange hubs because of the wide variety of modes, rolling stock and associated managers. This diversity makes it particularly difficult to match the height of the platforms to the height of the rolling stock as a whole;
- roads and public spaces are also an important theme to ensure the coherence and continuity of the development around the exchange centre. Accessibility planning is included in the accessibility plan for the roads and public spaces, which may be the responsibility of the municipality or inter-municipality.

The 2014 Ordinance designated a Transportation Organizing Authority (TAO) or Mobility Organizing Authority (MAO) as the lead authority for each stop. This lead authority is responsible for broad consultation with the various publics, users and associations representing all types of disabilities, and for orchestrating the actions of each of the stakeholders. Even if there is no coordinator for all the stops of an interchange hub, station accessibility is regularly addressed through interchange hub projects. This approach makes it possible to include accessibility in a more global project and to widen the range of potential partners and financiers.

A project of exchange pole must thus consider all these components of the accessibility chain and ensure the good articulation between them. It touches on different regulatory perimeters of accessibility and can suffer from the difficulty of bringing a global approach to the scale of the cluster. The objective is to limit the disruptive effects for all users, whether in the routing or in the information provided to passengers. This is why it is important to focus on at least one fully accessible route that is beyond the limits of the relevant authorities. For example, the municipality and metropolitan area of Poitiers took advantage of the presence of several construction sites to bridge a major difference in level and make a 1km pedestrian route between the city centre, the interchange and the station 100% accessible.

Recommendations
To create at least one fully accessible route, without interruptions in the journey and in passenger information, beyond the limits of each player's competence;
Extend the consultation set up at the design stage to guarantee a quick reaction in the event of a malfunction and to remain attentive to the needs of users;
From the design stage, think about the maintenance and management of guidance and information devices specific to people with disabilities.

3.5. The day-to-day exchange hub: what uses?

The inauguration of an exchange centre is usually an opportunity for the various players involved to congratulate themselves on the success of the partnership that made the project possible. In practice, the day-to-day running of the cluster is a telling indicator of the quality of this partnership: malfunctions can appear very quickly, and serve as a reminder that the involvement of the players must continue beyond the inauguration to guarantee the long-term success of the exchange cluster.

This fifth and last part deals with the issues related to the daily operation of the exchange centre, beyond the project itself. What should be planned in terms of signage and staking? What are the challenges of multimodal information? How to establish daily management methods? What can be expected from current service innovations? How can we organize ourselves to follow the evolution of uses and expectations?

3.5.1. Signage and staking in the exchange hubs

Matching conditions can be considered optimal when there is no need for special signage, guidance or assistance to make a transfer; i.e. when "space speaks for itself". Intuitive intermodality is possible when the destination and the route are directly legible upon arrival at the interchange. Seeing the vehicle arriving from afar can even give an indication of the time available and allow you to adjust your approach according to the situation by speeding up or slowing down the pace. Of course, these situations are satisfactory if they incorporate accessibility standards: visibility is not everything, especially for blind or visually impaired people who must be able to rely on sound guidance. The same applies to safety requirements, since it is sometimes essential to channel pedestrian flows, for example to avoid untimely crossings of the carriageway by streetcar users, to the detriment of the most direct routes. Thus, the question of signage is a complement, sometimes a palliative one, to the difficulty of legibility of the space.

In surface "urban" exchange hubs, we can focus on improving the visibility of the nodes without overloading the space with signage. It is the work of a street architect that must be considered: an intervention on the levelling and on all the emergences in the public space that may appear as obstacles.

Around railway stations, visibility cannot be total, taking into account access to underground or overhead platforms. However, for connected modes, the principle of the "gallery of modes" is spreading: it consists in creating legibility from the forecourt to all the other modes present: bus station, cabs, drop-off...

In labyrinths, which are often the largest exchange hubs, signage is indispensable in the face of the complexity of the spaces, and vital both for user orientation and for flow regulation.

Signage can be based on iconic (pictograms, logos, colours...) and/or linguistic semantics. The difficulty is that the information must be easily assimilated, because the eye does not formally "read" the message written on the sign, but tries to capture a "memory motif" (Meissonnier, 2015). Certain principles must therefore be respected in the exchange hubs:
- the hierarchization of the level of information given according to the path of the traveller;
- Continuity of information and homogeneity of media for support to the destination (no change of "language" during correspondence);
- legibility, intelligibility and accessibility of indications: signage must be adapted to all disabilities. Sometimes certain digital tools assist physical signage, which cannot meet all needs.

These principles give rise to a certain amount of creativity in the staking out of pedestrian routes in places of exchange, for example:
- the use of common materials (plots, palisades) as ephemeral support;
- the marking of pathways by ground signage;
- the identification of different routes according to the time available (direct, commercial or bucolic routes);
- the "playfulness" of the public space through drawings, works or furniture;
- the enhancement of pedestrian continuities by atmospheres more than by panels (for example a light garland to reveal a path).

Recommendations
Adjust the need for signage by avoiding an overabundance of signals or information;
Ensure qualitative staking that takes advantage of its environment (heritage, alignments of trees and other elements that can be seen in the urban space, etc.);
Pay special attention to management and maintenance: premature aging of a panel can lead to a lack of continuity in staking.

3.5.2. Multimodal information and the potential of digital technology

Multimodal information is one of the essential functions for the proper functioning of a hub. The physical articulation of the modes of transport must be accompanied by comprehensive information on the transport offers in question, whether or not they come under the responsibility of the same operator. The aim is to provide passengers with efficient, shared information to make intermodal travel safer. In an ambitious way, multimodal information in transit hubs may seek to go beyond theoretical timetables (real time or even predictive), beyond the administrative perimeters of the various networks, and beyond public transport modes (including non-authorized modes).

The sharing of physical spaces for the reception, sale of securities and multi-operator information in exchange hubs often remains complex. The sharing of personnel remains difficult and the cohabitation in the same space of agents of each carrier is generally favoured. In hubs with no reception staff, brochures, network maps and other information are grouped together in the same place.

Digital signage tends to develop because it offers a dynamic solution to the diffusion of information. We more frequently find information totems or digital walls that allow the digitization of evolving information. This new equipment allow to reduce the number of fixed panels. The digital display of information implies solving technical and institutional questions: how to make different information formats cohabit (generally: theoretical time of passage for trains, real waiting time for buses) or modes that have a very different frequency? Who manages what in terms of updating information, disturbed situations or equipment failure when the display is common to several actors?

Through connected personal objects (smartphone, tablet...), applications open the possibility to offer not only dynamic but also personalized information. The advantage is no longer to be drowned in a mass of multimodal information, but to parameterize an individualized need: for example, vigilance on a particular correspondence, guidance according to specific criteria for a person with reduced mobility, sound information for visually impaired people.

This personalized and dynamic information can change the "experience" of the correspondence and the behaviour of users:
- the dematerialized smartphone ticket no longer requires you to go to the ticket office to buy or exchange a ticket, or even to punch or park in front of fixed displays;
- guiding aids increase the possibilities of providing information to users in all their diversity: these applications remove the limitation/difficulty of understanding signs and guidance panels;
- other applications now make it possible to choose one's wagon, in the metro, RER or streetcar, in order to optimize one's connection to a given station.

These innovations, made possible by the opening up of data from operators and managers, could in the future involve an additional level concerning services or commercial activities in the exchange hubs: these may find it useful to be identified along the user's route in order to take advantage of waiting time (purchase, approach, etc.).

With digital technology, information can also be exchanged directly, horizontally and collaboratively, rather than exclusively in a top-down fashion: information transmitted from the transportation operator to the passenger is now supplemented by information produced and exchanged between passengers. The permanent connection of certain users to social networks (such as Twitter) makes it possible to multiply the sources of information in near real time and in a very reactive manner. The paradox is that passengers are sometimes better informed via digital technology than the reception and information staff themselves! However, this decentralization of information should not be a cause of disengagement on the part of transportation operators: the quality and quantity of information exchanged is uneven, depending on the location. The reliability of this information is a major issue for mobility operators, and may even become a challenge for potential "community managers" of transit hubs in the future.

Finally, the flexibility offered by digital applications has a cognitive cost. Many users are de facto excluded from the full use of these innovations if they do not own a smartphone. And even though they may own connected objects, surveys show that the vast majority of users have a basic use of these devices. Digital information does not therefore replace physical information; rather, its increasing power should lead to a rethinking of the way in which new technologies and more traditional channels are linked. The attitude of some carriers consisting in targeting an exclusively connected clientele (no fixed information, store or physical ticket purchase) may in this sense appear very restrictive and socially selective.

Recommendations
Maintain a diversity of information vectors to meet the need to reach all audiences;
Seek an opening (and interoperability) of the data of each carrier and manager of the exchange pole in order to stimulate creativity in terms of applications for users;
Highlighting the role of users as the primary source of information, encouraging the dissemination of information on social networks and animating communities of users of exchange hubs.

3.5.3. Day-to-day management procedures

The management of a hub refers to different components depending on whether it concerns spaces, buildings, equipment, infrastructures, services, technical systems for transport and regulation of the various flows they generate. A distinction can be made as follows:
- classic" management missions: site maintenance, security, basic reception and user information functions. They constitute the basis of the operation of a hub, just like any other facility;
- specific missions related to the operation of the transit hub as a connection point for different transportation networks: information on transportation networks, multimodal information, ticket sales, management of parking lots, commercial areas and locations, and systems to assist in the operation of transportation lines in order to optimize connections.

The practical and contractual terms and conditions for the management of exchange hubs are rarely anticipated during the project set-up and construction phases. Too often, we are therefore in the situation of juxtaposed management: each institution manages its perimeter autonomously, without any real consultation with the other operators in the exchange hub or any requirement for common standards. However, from one player to another, the rhythm of the most traditional maintenance missions (cleaning, minor maintenance) is not the same. In addition, the players involved are rarely all represented on the site, which is not without its problems in terms of technical monitoring of equipment operation.

The lack of coordination of management missions thus generates various problems:
- border effects" between the territories of the different managers, which are very detrimental to the coherence of the exchange pole;
- the lack of joint monitoring of the cluster's development and a lack of responsiveness of the partners concerned when a major problem arises;
- the obligation to carry out corrective interventions, on a case-by-case basis, depending on the malfunctions or defects observed: wear and tear or premature deterioration of certain equipment or coatings, maintenance failures, recurring problems encountered by users.

Unified management, which on the other hand would imply that the various players entrust a single manager with the deployment of functions and services across the entire perimeter, is an ideal solution. However, it is often illusory or impossible to implement, as partners generally want to retain a minimum of prerogatives in this area. Therefore, this means looking for ways to coordinate the future management of the cluster. It is therefore essential to jointly clarify all the missions to be carried out, their concrete execution methods (including the planned rhythms and periodicities), and to define the commitments and quality standards to be sought. The establishment of a management or operating agreement that is regularly monitored makes it possible to formalize all of these commitments.

Recommendations
Anticipate as early as possible, as early as the design phases, the main lines of the management methods and possible difficulties;
Clarify in common the management missions necessary for the operation of the exchange centre;
To draw up an agreement / protocol relating to the future management of the cluster, listing for each of the missions to be carried out at their own pace, the conditions of financial support according to the skills of the different partners, their technical conditions of implementation, the main coordination to be ensured, the criteria to be taken into account, the methods of carrying out technical monitoring of the different facilities.

3.5.4. When services redesign intermodal locations

What changes will mark the exchange hubs over the next ten years? While the advent of new mobility systems cannot be ruled out, given the abundance of private initiatives in this area, it is undoubtedly in the world of services and commercial activities, which is currently undergoing rapid and profound transformations, that the main changes are to be expected. This "service" dimension is nowadays increasingly considered at the project definition stage for exchange hubs, but experience shows that it also brings with it a dynamic of permanent transformation and evolution of these facilities.

A major player in this field since its creation in 2009, Gares & Connexions is stepping up the transformation of major stations with an unprecedented ambition. In the medium term, the major stations in Paris and regional cities will host several thousand square meters of renewed commercial activities, diversified in terms of both product types and range levels. Half of the revenue generated by the stations (1.2 billion in 2015) will come from real estate and commercial activity. By 2023, Gares & Connexions plans to double the contribution of retail outlets to this revenue. With this in mind, France's station manager is continuing the process of setting up retail space in large stations and is embarking on the experimental deployment of "everyday stores" in small and medium-sized stations.

At the same time, beyond the commercial function alone, the range of services offered to passengers in stations continues to diversify. While there is a real momentum for experimentation, some more advanced initiatives are now in the deployment phase and are making it possible:
- for the user, to take advantage of waiting or connecting times, for example by working for a few minutes in dedicated areas that allow them to be relatively isolated while monitoring departure times, to save time or money on travel by dropping off or picking up various goods in return delivery systems (parcels, shopping carts, dry-cleaning clothes, etc.), making emergency purchases, administrative procedures, medical analyses, etc..;
- for local authorities and operators, to make the most of under-used areas or buildings, to ensure a human presence and a lively environment, for example by setting up a public service (media library, crèche or day nursery, multi-service information and mediation points, etc.), shared work spaces, association premises, or by proposing temporary artistic, cultural or festive events...

These various innovations show that places of mobility, whatever their scale, are gradually changing through the integration of additional services into their primary, technical functions. Stimulating as they may be, these experiments need to be monitored and evaluated in order to assess the expectations they meet and their level of appropriation by users. Beyond the experimentation phases, the economic conditions for their sustainability are also in question. The economic model for the operation of services in transport hubs is still to be invented. If the economics of services in SNCF stations today meet the principles established by the decree of 20 January 2012 on passenger stations and other service infrastructures in the rail network, these could evolve in the coming years. Moreover, they only concern the spaces of the railway world and therefore do not respond to the problems of setting up services in multimodal transport hubs where the porosity of mobility and spaces plays on institutional boundaries. Finally, the current desire to bring new services to users and to offer them multiple ways of optimizing their time should not obscure the fact that a transport hub must also provide spaces that simply offer the possibility of a moment of rest and relaxation.

Recommendations

To promote experimentation in the field of services by seeking, beyond a single market logic, the diversity and the social or collaborative value of services;

Evaluate and capitalize on the lessons learned from these experiments in order to make them evolve;

Mobilize citizens and civil society to encourage, support and influence experiments in terms of services and facilitation in the exchange hubs.

3.5.5. Monitoring usage and satisfaction to better respond to expectations

The weight of technical and organizational logic often leads to neglecting the diversity of the public ultimately concerned by the exchange centre. Several transit hubs thus seem to be designed only for regular users of transport facilities and networks, or for a "user" considered in a singular and generic manner. However, a regular passenger is a case that by no means exhausts the variety of uses of the modes of transport; as for the user in the singular, it masks the diversity of uses of a transit hub at different times of the day, week or year, as well as the diversity of the publics concerned and the expectations they have.

More or less occasional travellers, local residents using the services or shops present, people with reduced mobility... While it is not easy to ensure that these different user profiles coexist and to design facilities that meet all expectations, it is essential that the design of the centre allows for a diversity of uses, from optimizing and seeking to make the routes more efficient, to providing information, providing rest times and places to rest, and so on.
In the project phase, the future uses of the exchange centre are imagined. Even if yesterday's practices have been correctly observed and analysed, care must be taken not to overly rigidify the orientations of the facilities supporting tomorrow's practices. In fact, uses can evolve quite rapidly while project completion times are sometimes long: this is the observation that can lead to a certain degree of evolution in the developments and a preference for flexible and adaptable solutions.

The first steps after commissioning are important in order to avoid long-term detour of use. The commissioning of the exchange centre is the moment when the project is confronted with user practices. Some regular users will have to change their practices, which often requires support. Indeed, the weight of habits in mobility behaviour can lead passengers to maintain practices that are no longer compatible with the development choices. It is therefore important to ensure that the intended use is respected, otherwise malfunctions will have to be dealt with: helpful and fun signage, or the presence of facilitators at certain times, can contribute to this gradual appropriation of the premises.

There are several methods for monitoring function and making adjustments. Surveys measuring, for example, a satisfaction rate can be preferred. Gares & Connexions relies on a "satisfaction barometer" fed by face-to-face surveys once a year for the main stations. Users are questioned on the "five promises" of Gares & Connexions services: information, travel, cleanliness and safety, comfort, shops and services.

There is an obvious interest in maintaining an active watch and listening to the public in order to anticipate malfunctions. Regular consultation with transport users' associations can be a first step, as can the involvement of line committees (coordination bodies set up by the regions) on the specific subject of transport hubs. Where they exist, hub committees have the legitimacy to undertake this process of listening and diagnosis, and to make changes to the facilities and management methods accordingly.

Recommendations
- To preserve as much as possible margins for evolution and adaptation (choice of certain materials, use of removable or transitional arrangements, etc.);
- Accompany users after commissioning to explain the principles of development and facilitate the appropriation and respect of the site;
- Define between partners a rhythm for monitoring user satisfaction (surveys, barometers, etc.) by closely associating the operators;
- Create a cluster committee that will meet regularly to conduct any useful diagnosis in order to improve the daily functioning of the exchange cluster.

3.6. Conclusion

Exchange hubs are, by their very nature, receptacles for innovation and are therefore in perpetual evolution. The growth of exclusive right-of-way public transportation introduced since the early 2000s, the deployment of self-service bicycle systems over the last decade, or more recently the emergence of carpooling systems or intercity bus links, all these changes have increased the possibilities offered to users, while at the same time adding additional constraints to the designers and managers of transit hubs.

Faced with a moving object with increasing functionality, the need for a global and coherent vision is all the more crucial:

- the unity of the object does not only refer to the coexistence of different elementary components (the park-and-ride facility, the bus station, the bicycle station, etc.), but also to the capacity of public policies to formulate a coherent conception, beyond the territorial scales, of the poles of exchange;

- the unity of the project, for its part, can only be built over time, through the synergy of institutions which, if they do not share the same objectives, meet around common interests;

- unity of action in the management of projects often depends on the quality of partnership governance. This is often nourished by stages that formalize mutual commitments (protocols, conventions, various contracts, etc.), but it is not limited to these. The scope of the partnership or the way in which project management is organized, while obeying a few important rules, always involves finding the formula best suited to the local context;

- the unity of place refers to the overall composition and dimensioning of the spaces, and the need to reconcile the heritage of the place, the present constraints, the changes to be anticipated, and also the assertion of choices for development over the next ten to twenty years. This unity of place also refers to the way in which the populations, users, local residents and various users perceive and use this facility. Encouraging the appropriation of these objects remains a challenge for the public authorities;

- the management unit, finally, is essential to ensure the operation of the exchange hub. In the absence of a single solution or a foolproof method for regulating the "daily" inter-modality, for detecting and resolving malfunctions while remaining attentive to changes in usage, collectively formulating a requirement in this area is already an essential first step.

An important development in recent years is undoubtedly the renewed interest in walking in places of intermodality. Concern for pedestrians, their paths and constraints, is also the best way to act for the urban integration of transport hubs. By remaining in permanent contact with his urban environment, the walker redefines the scale of use of intermodal hubs, which can no longer be satisfied with simply linking distant space without communicating more with the nearby space. More broadly speaking, while we cannot erase their congenital technical dimension (to make the different networks converge), the current conceptions of exchange hubs mark a turning point towards a more assertive urban dimension. Today, more than in the past, exchange hubs are seen as true urban centralities, as important appointments with public space, which encourages new skills and professions. By titling Les places du Grand Paris to talk about hubs of exchange, the publication of the Société du Grand Paris is affecting a semantic shift that symbolically testifies to the new role of intermodality. These places, where we have sought to make passage and correspondence efficient, are also becoming places where we seek to make stops attractive, where we affirm the primacy of social relations and public space over that of traffic.

Chapter 4

Intermodal travel costs

Introduction

The concept of travel cost is a very sensitive element in the choice of transportation modes for passengers or in urban transportation network planning for communities. The internalization of all significant correlative costs associated with passenger travel is the crucial and exclusive focus of this section.

The probability of access to an attraction zone does not depend solely on the number of coveted goods or services present in that zone. A good that is available nearby is more attractive than one that is distant and therefore costs time and money for travellers. However, sustainable urban transport development cannot be considered only from the perspective of the traveller, to which it is necessary to add the collective costs. The concept of "generalized cost of transport" characterizes the valuation of transport time and the monetary costs actually incurred by passengers. A sustainable perspective thus considers other costs as the public expenditures required to provide infrastructure and services, and the external costs borne by the population and the environment. These costs need to be assessed.

Encouraging the use of public transport, nonmotorized modes, and their combination is a clear and priority development direction for transport policies, with the objective of reducing the rate of private motor vehicle use and dependence in densely populated areas in order to reduce most negative externalities, create a pleasant environment, improve road safety, and so on.

However, this objective is above all that of the public authorities, with the exception of safety, which is partly taken into account by users. Passengers choose a mode of transport that combines a reasonable expenditure of time and money with a minimum of comfort. Few users abandon their individual motorized vehicles in order to improve the current urban transport situation if their vehicle is more competitive with public transport or non-motorized modes. In order to integrate the views of passengers, public authorities and society, the cost approach was motivated by the possibility of comparing different modes and trips by territory using a single indicator that includes all monetary costs.

Existing theoretical models attempt to explain behaviour through monetary and temporal cost factors:
- the generalized cost theory used in typical four-step aggregate models aims to consider the traveller's route choice, including explanatory travel time and costs that converts all factors into monetary values;
- the conjecture of Zahavi (Zahavi, 1979) defines a relative constant of the time budget devoted to daily travel. In other words, the daily time spent on travel has remained constant despite territorial changes, partly due to the advent of the automobile. The greater the speed, the greater the territorial space, and the longer the day's travel time does not change;
- the rational choice model, a theory that postulates the individual compares the different alternatives in terms of cost and time in particular, and chooses the most advantageous one;
- the Prud'homme approach, that the time saved in travelling is one of the main factors in the choice of means of transport.

The monetary costs of travel are not, however, taken into account as a whole in mobility analyses, even though they are essential for understanding individual mobility choices. This is the case, for example, for the costs of equipping individuals with vehicles, infrastructure costs for communities or external costs for society as a whole. We will therefore propose a method for evaluating the total cost of travel (TCO) in order to truly reflect, on the one hand, the behaviour of passengers in their choice of mode and, on the other hand, the coherence of transportation policies for communities within the framework of sustainable development.

Encouragement of public transport use should not just be a political slogan, but a debate about the advantages and disadvantages from the passengers' point of view. Can passengers really find a benefit in replacing their motorized vehicles with public transport, non-motorized modes, or both? Should motorists pay more for their social responsibility? We will attempt to quantify the travel costs associated with the different perspectives in order to indicate precisely the points of potential contradiction between private logics and the control of public and external costs. In order to carry out this comparison, the calculation of each cost will be disaggregated as much as possible. This disaggregation of travel costs between different categories of travel characterized by mode use and type of geographic link provides valuable information for the socioeconomic evaluation of contemporary and future transport policies.

Efficient and fair urban transport pricing

High motor vehicle use is mainly caused by the expansion of urban areas and the development of sparsely populated outlying areas that are difficult or even impossible to serve by public transport at an acceptable cost. Walking, cycling, and public transport use has declined in the post-war decades to the present day in many areas, dependence on motorized vehicles has become widespread, and distances travelled are continually increasing. This increase in distance travelled, and the growth of the automobile market at the expense of public transport, cycling, and walking, has reduced or even eliminated the effects of the technical progress made in automobile technology. The most sophisticated traffic management systems also have only a limited effect on the level of traffic congestion and have no major influence in the long term.

For motor vehicle enthusiasts, the solution to congestion is the construction of new road infrastructure. In cities, the sustainable improvement of traffic conditions and the environment depends on controlling the use of the motor vehicle and not on a perpetual race to invest. Building more and more roads is not an option in urban areas: the growing opposition of local residents concerned about the nuisance that these infrastructures would impose on them leads either to abandon projects or to raise their prices considerably to make them acceptable.

Towards a cost-based system of urban transportation planning

Urban mobility policies are often inefficient and inequitable if they are not based on regulating the travel market through a price system that reflects all the costs generated by the various modes of transport. These costs include: the internal costs, including private costs and capital and operating expenses, of individual and public transport modes; and the external costs related to negative environmental impacts, accidents, noise, congestion, etc., and the costs to the environment.

The current situation is unsatisfactory: the pricing system often poorly reflects internal costs and takes insufficient account of external costs. The publication by the European Commission of the Green Paper (1995) "Towards Efficient and Fair Transport Pricing" "opened up interesting prospects for the implementation of such a pricing system. The urban transport sector is particularly concerned with more than 91% of Japanese living in cities (MLIT, 2017), air pollution affects almost exclusively urban dwellers, and almost all congestion is located in urban or peri-urban areas.

In line with the description of urban transport pricing, we know that the evaluation of the total cost of travel (TCO) across the different dimensions includes many items and must also rely on comprehensive databases in order to establish a travel cost system. Moreover, most current international research on travel cost analysis focuses only on user costs. In contrast, there is little research that analyses the total cost of overall travel within the urban transport system.

A majority of transportation policies in the contemporary world are aimed at encouraging the use of public transport and reducing reliance on motorized vehicles. These policies focus primarily on reducing total social costs, reducing the expenditure of social resources, and ensuring a fair and reasonable distribution of social and territorial resources. However, policies on public financing, fare regimes, public subsidies, and controls for urban transport also need to be considered on the same diagnostic platform. Our research in the second part therefore proposes to build a comprehensive analytical model to quantify travel costs.

Failure to take account of the external cost in transport policies in the past caused a significant increase in the number of PV in the past; this external cost is playing an increasingly important role in sustainable policies. Therefore, our model must also quantify the detail of external costs by mode. In sum, we need to set out in detail the process of assessing travel costs in the following sections. Finally, in order to diagnose the relevance of sustainability measures to encourage the use of public transport, non-motorized transport, or intermodality, we aim to develop a diagnostic method based on the outcome of travel cost assessment.

4.1. The components of the global travel cost and its analysis model

The overall cost of travel is a benchmark against which passengers can choose a more reasonable and sustainable mode of transportation for their daily trips. In addition, passengers are increasingly accustomed to travelling with connections in dense urban spaces, favouring the diversity of transport modes and their intermodality. However, what cost of travel is actually paid by users or borne by communities? We clearly need to know the cost structure for a trip in order to optimize the distribution of economic, social and territorial resources.

The disaggregation of travel costs between different categories of travel characterized by mode use, type of geographic link, and time slot is a key piece of information in the socioeconomic evaluation of transport policies. It is necessary, in particular, for comparing the efficiency of transport modes in different geographical areas, for measuring the impact of investment or resource optimization choices between different economic actors, and for developing a differentiated fare system (Auzannet and Bellaloum, 1993). Several recent studies have already developed a comparative analysis of the socio-economic efficiency of PV and PT travel, with emphasis on spatial and temporal variations in costs.

4.1.1. Definition of costs

Before evaluating travel costs, we first need to understand the components of the total cost of travel for users and authorities in order to disaggregate them more precisely. In addition, the overall cost of travel is mainly separated into two parts: monetary and non-monetary costs.

The analysis of direct monetary expenditures on passenger transport is based on the estimation of the cash flows from economic actors to different activities, characteristics, or associates. The objective of this analysis is to know who spends, how much, and on what activities. Total regional expenditure thus includes expenditure on all operations that contribute to the development, maintenance, and operation of the passenger transport system, such as the acquisition, operation, and maintenance of PV and the creation and maintenance of PT and road infrastructure. Expenditure is presented both overall and by activity. It is broken down between operating and capital expenditure.

The analysis of non-monetary transport expenditures includes external costs (air and noise pollution, congestion, accidents, etc.) and the cost of travel time. These non-monetary costs must also be considered in an economic approach to show the true total cost of a trip. The study of these components and their sum can inform pricing practices, i.e. the proportion of the cost that is charged to users. There are two major options for travel pricing (Gallez, 2000).

Marginal social cost pricing is an estimate of the expenditure to the community of an additional pkm on a given network. This expenditure includes the direct costs of maintenance and operation, as well as overhead costs related to nuisance, insecurity, and congestion. This option is most consistent with the formalism of marginalist economic theory, in particular by passing on to the user the costs that his or her passage on the infrastructure causes others to bear, as well as a contribution to the costs of future investments that the increase in traffic will make necessary on the infrastructure that it contributes to saturating, if one finds oneself in this situation. This approach is considered relevant in the event of an increase in traffic.

Full-cost pricing allocates to the user all operating and capital expenditures as well as external costs related to nuisances. This option aims to ensure a balanced budget and is similar to financing pricing: the tax levies corresponding to energy products taxes are considered to contribute to the coverage of environmental externalities in the given region. This approach is considered relevant in a stabilized system (Brossier, 1999).

4.1.2. Disaggregation of overall travel costs

We can break down the total cost of travel (TCO) into two main parts according to the monetary nature: monetary and non-monetary. The monetary cost includes the perceptible cost, such as private and public cost, and the non-monetary cost consists of the external and private costs via the value of time. The overall cost of travel is therefore composed of private, public and external costs.

The private cost corresponds directly to the monetary expenditure borne by users of the transportation network and by employers, who contribute to the financing of PT reimbursements example, 50% reimbursement of the amount of the orange card in Ile-de-France and bear the cost of parking at the workplace. In Japan, a similar system (teikiken) takes place. The private cost also includes the value of travel time spent on daily life, although the value of time belongs to the non-monetary cost in the cost typology. Implicit here is the assumption that employers' expenditures on public transport and parking are balanced by the benefits they derive in terms of recruitment and productivity. This assumption is often justified in large urban areas, less so in smaller cities.

The public cost corresponds to the expenses borne by public authorities (e.g. the cost of infrastructure and rolling stock) less the expenses borne by users and the taxpayer. This public cost must also take into account the consumption of space, particularly for road transport modes, since the land cost of roads remains invisible to users.

The external cost is the result of estimating the costs related to the environmental nuisances caused by all modes of urban transport, such as air and noise pollution, the greenhouse effect, insecurity and traffic congestion. The method of evaluating external costs still varies widely to this day, but it is still essential to propose reasonable values in order to rebalance the distribution of travel costs on the one hand, and to simulate a more real situation on the other.

When analysing people's behaviour, we usually distinguish between perceived costs that directly influence the choice of transport mode and those that do not. Perceived costs consist of ticket purchases or the share of the fare paid by users for public transport trips; the cost of fuel, maintenance, and parking for PV trips; and the time spent on transport for both categories. Travel time is a non-monetary cost and should therefore be valued in monetary terms. Costs not felt per user in the second part of the cost of travel include, for motorists, amortization of vehicle purchase cost, vignette, insurance, etc., and the cost of fuel, maintenance, and parking for PV travel.

Private costs normally take into account the taxes on travel and thus reflect the expenses actually borne by users. Public expenditure, on the other hand, is estimated after deducting tax and fare revenues from users and public transport companies (STIF, 2005 and Gallez, 2000).

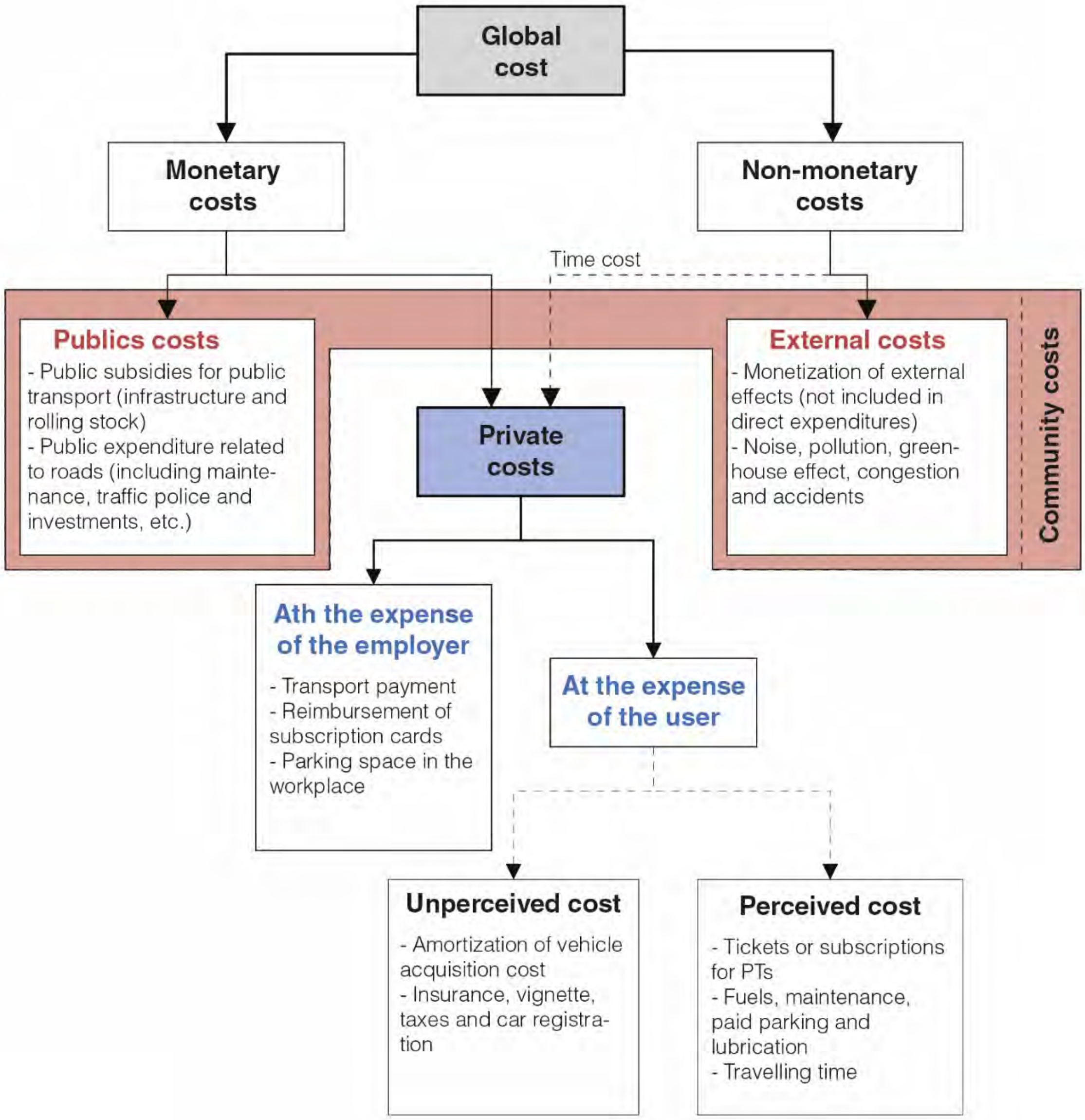


Figure 4.1.1. Overall travel costs breakdown

Source: Created by the author

Current structure of costs felt by travellers with costs to the community

The mobility behaviour of city dwellers is driven by their appreciation of their transportation spending. The notion of perceived cost is a determining factor in the decision to travel, and in the choice of mode, time and place. The cost to the community includes operating and capital expenditures as well as external costs. These costs can also vary greatly depending on the area in which the trip takes place. In order to support these different points of view proposed on travel costs, we will evaluate them in the next section after having assessed all travel costs.

4.1.3. International definition of cost composition

There are other ways of breaking down the overall cost of travel, including the framing of the analysis of its cost for individual vehicles, buses and rail modes. The overall cost of travel is then made up of three main parts: the cost of equipment, including the cost of maintenance, acquisition, etc.; the cost of transport equipment, including the cost of maintenance, acquisition, etc.; and the cost of transport equipment, including the cost of maintenance, acquisition, etc. The external cost represented by the cost of time and negative externalities. The individual monetary cost including the cost of fuel, insurance, etc. (Qin, 1996).

The total travel costs of transport modes can also be divided not only between internal and external costs, but also between fixed and variable costs, related to the shape of the market or not (Litman, 1996). The cost of time, for example, is an external, variable, non-market cost. Figure 7-2 shows how, according to this cost analysis, it is possible to organize and show this composition according to the respective characteristics of the various costs.

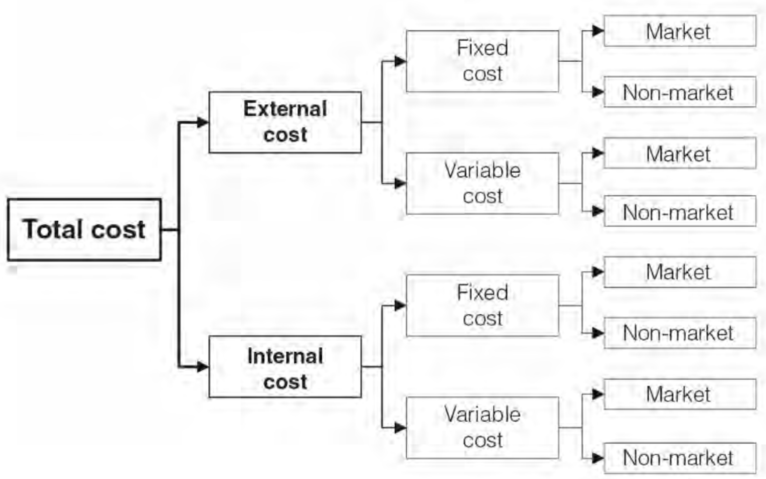


Figure 4.1.2. Total travel cost diagram

Source: Created by the author

Since the total cost of travel includes all costs produced in travel behaviour, it is necessary to analyse the different costs according to the modes.

4.1.4. Travel cost category

After classifying the overall cost of travel, as the number of costs in a trip can be high, it is necessary to discriminate the most important ones. Litman's study indicates precisely the different costs for travel modes in a North American context, listed in Figure 4.1.3 in three categories: internal fixed costs, internal variable costs, and external costs. In addition to time, parking or ownership costs, external costs can account for up to one-third of the total cost of automobile travel and must be considered in a travel cost analysis.

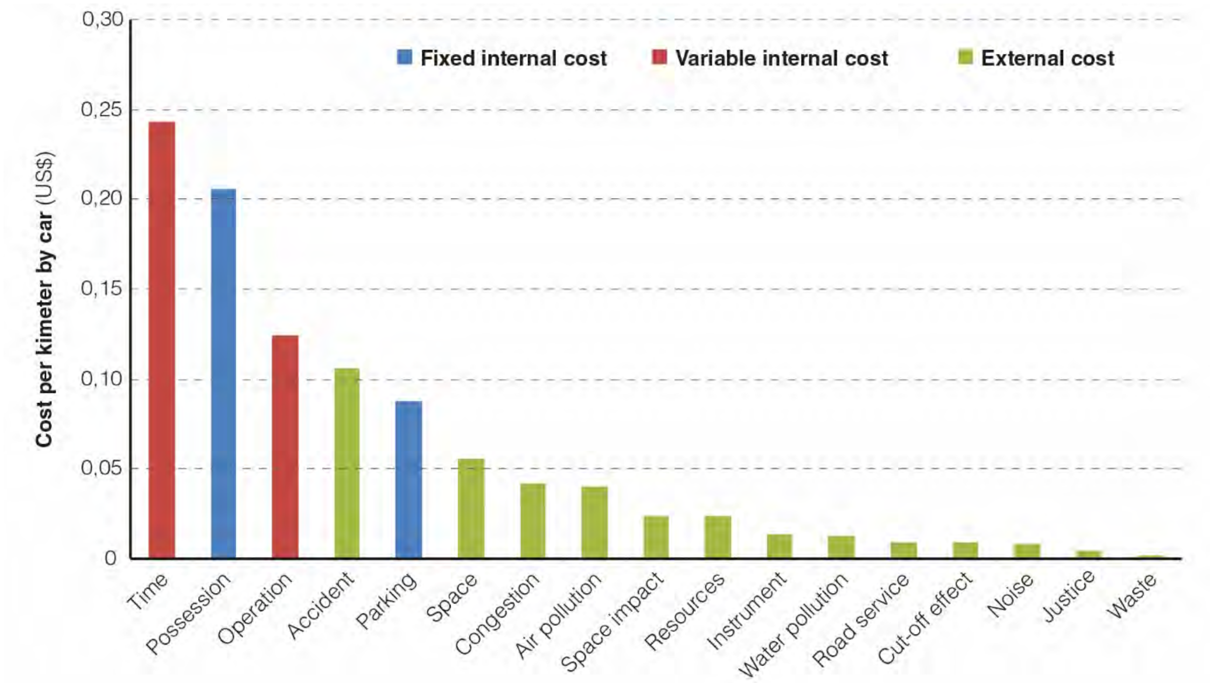


Figure 4.1.3. Private vehicle travel costs

Source: Litman, 1996

These costs will therefore be detailed in three parts in the sections 4.2 to 4.5. The first part will be devoted to private costs in sections 4.2 and 4.3. The private cost is composed of annual fixed and variable costs. The second part will address the public cost in section 4.4. The third part will be devoted to external costs in section 4.5. These three categories of costs account for about 95% of the total cost of travel.

We first aim to analyse the most important travel costs according to the difficulty and complexity of data collection and the diversification of travel costs. To this end, we present the twelve cost items selected in Figure 4.1.4.

Cost	Description	Market / non market	Internal/external	Fixed/ variable	User/ other	Felt/ not felt
		Private cost				
Acquisition of the vehicle	Amortization cost of the vehicle	Marketplace	Internal	Fixed	User	not felt
Vehicle Operation	Cost of use	Marketplace	Internal	Variable	User	felt
Insurance, tax etc.	Cost of insurance, vignette etc.	Marketplace	Internal	Fixed	User	not felt
Travelling time	Travel time value	Non-market	Internal	Variable	User	felt
		Public cost				
Operating Expenses	Infrastructure and rolling stock for CT and roads	Marketplace	External	Fixed	Other	not felt (except revenues through pricing)
Maintenance Expenses	Public expenditure related to maintenance and commissioning.	Marketplace	External	Fixed/ Variable	Other	
Space consumption	Cost of space consumption related to the land	Marketplace	External	Variable	Other	
		External cost				
Air Pollution	Vehicle Emission Cost	Non-market	External	Variable	Other	not felt
Noise	Vehicle noise cost	Non-market	External	Variable	Other	not felt
Greenhouse effect	Cost of the greenhouse effect	Non-market	External	Variable	Other	not felt
Accident	Cost of accidents not borne by the user	Non-market	External	Variable	Other	not felt
Congestion	Increase in delays, in addition, it can affect other road users.	Non-market	External	Variable	Other	not felt

Figure 4.1.4. Categories of travel costs

Source: Created by the author

These travel costs will be presented in Sections 4.2 to 4.5. The remainder of this section aims to establish an internal and external cost algorithm model for the overall cost of travel.

4.1.5. Literature review on transportation costs

This section aims to present historical studies on the theme of transport costs around the world. The various studies present a variety of intentions that may affect their respective perspectives, methodologies, and scope. As a result, the following relative factors need to be considered in the evaluation of transport cost:
- analysis intention, perspective, marginal cost, average cost and total social cost;
- the categories of impacts considered, including vehicle costs, travel time, roadways, parking, accidents, congestion, etc;
- database sources and valuation methodologies for calculating transportation costs, including non-market costs such as accident costs and environmental damage;
- the geographical dimension and the monetary exchange rate for the different countries or cities;
- types of vehicles.

We list on figure 4.1.5 some thirty studies on travel costs over the last fifty years around the world.

Author	Year	Article	Description
Keeler, et al.	1975	The full costs of urban transport, intermodal comparisons	Comparison of costs, including congestion, utility, noise, air pollution, accidents and parking costs, for the automobile, bus and rail modes in San Francisco.
Hanson	1992	Results of literature survey and summary of findings	This report identifies the external costs for urban roads and describes the methods for calculating costs.
Kageon	1993	Getting the prices right : a European scheme for marking transport pay its true costs	This study aims to estimate the costs of pollution, CO2, noise, accidents and infrastructure for European countries.
KPMG	1993	The cost of transporting people in the British Columbia lower mainland	This study develops a cost estimate for twelve modes based on local research and generic estimates.
Works Consultancy	1993	Land transport externalities	This comprehensive study aims to streamline transportation planning. It attempts to describe all the external costs of road transport and to identify evaluation methodologies.
ENG (Federal railroad administration)	1993	Environmental externalities and social costs of transportation system	This study describes the various social costs associated with the motor vehicle, and at the same time it includes two charters that present the two typologies of transport costs.
Apogee	1994	The costs of transportation	Estimating the cost of accidents, congestion, parking, road equipment, services, pollution and Noise. The research cost model is developed according to three levels of urban density, at peak and off-peak times.
CEC	1994	California transportation energy analysis report	This report attempts to fully assess the economic and environmental costs for internal combustion engine vehicles. The costs include the cost of congestion, accidents, services, pollution, infrastructure and energy security.
Boiteux	1994	Transportation: for a better choice of investments	The report proposes to take into account the impact of projects on the environment and safety (including the cost of human life, noise and air pollution), so that transportation development is part of a sustainable development approach.
Poorman	1995	Estimating marginal monetary costs of travel in the capital district	This study describes the cost structure and evaluation model with monetized measures and costs to estimate transport investments and policies.
Lee	1995	Full cost pricing of highways	This report aimed at analyzing optimal prices for economic efficiency and for motor vehicle modes.
IBI Group	1995	Full cost transportation pricing study	The purpose of this study is to estimate the costs for the truck, rail and car modes in Canada. The costs were divided into three parts: private loaders, external costs and major subsidies.
Maddison et al.	1996	The true costs of road transport	This book proposes economic efficiency and equity to deal with the externalities of road transport. It develops the method for assessing external costs, including the cost of pollution, noise, congestion, accidents, and road equipment, in Great Britain.
Delucchi	1996	Annualized social Ccost of motor vehicle use in the United States	The series of 20 overview reports attempts to identify, categorize and estimate motor vehicle costs in the United States.
Christopher et al.	1997	An analysis of the full costs and impacts of transportation in Santiago de Chile	This study is the first comprehensive search for transportation costs in developing countries including parking, congestion, and road environment costs.
FHA (Federal Highway Administration)	1997	1997 FHA cost allocation study final report	This report represents the various categories of motor vehicles to which the costs charged to the highway system are allocated.
Gunther et al.	2000	External environmental costs of transport	This article provides an estimate of external costs for car, bus, rail, air based on four European case studies (INFRAS/IWW, EU Green Paper, ECMT and ZEQ-QUITS).
Banfi	2000	External costs of transport : accident, environmental and congestion costs in Western Europe	This study develops the method for assessing accidents, noise, air pollution, climate change, congestion and non-environmental effects for the four modes of transport (road, rail, air and inland waterway) in 17 countries in Europe.
Sansom	2001	Surface transport costs and charges	This research compares the social costs for the road and rail modes.
Boiteux	2001	Transport: choice of investments and cost of nuisances	This work updates or completes some of the quantification that had been proposed in a previous report to assess the main impacts of nuisances to be taken into account in the socio-economic balance sheets of transport infrastructure projects.
INFRAS / IWW	2004	External costs of transport (update study)	This final report updates the report in 2000 to improve the estimation of external costs.
Quinet	2004	A meta-analysis of western European external cost estimates	This paper compares transport cost results from 14 studies for western European countries between 1998 and 2003.

Figure 4.1.5. Transportation cost studies literature review

Source: Created by the author

4.1.6. The global travel cost analysis model

Most urban transport policies around the world aim to encourage the use of public transport and non-motorized modes, particularly in dense areas. The aim of these policies is to create a more sustainable city, but the different cost items associated with the policies remain difficult to distinguish.

The aim of this section is therefore to propose a model for analysing travel costs that can, on the one hand, diagnose the benefits of using transport modes and, on the other hand, answer questions related to the implementation of measures in the context of sustainable development. The assessment of the overall cost of travel includes many detailed costs, and the first step in this work is to collect comprehensive databases in order to accurately estimate the costs of travel.

4.1.6.1. Definition of mode ratings

We distinguish seven modes of urban transportation for which we seek to formulate a total cost of travel.

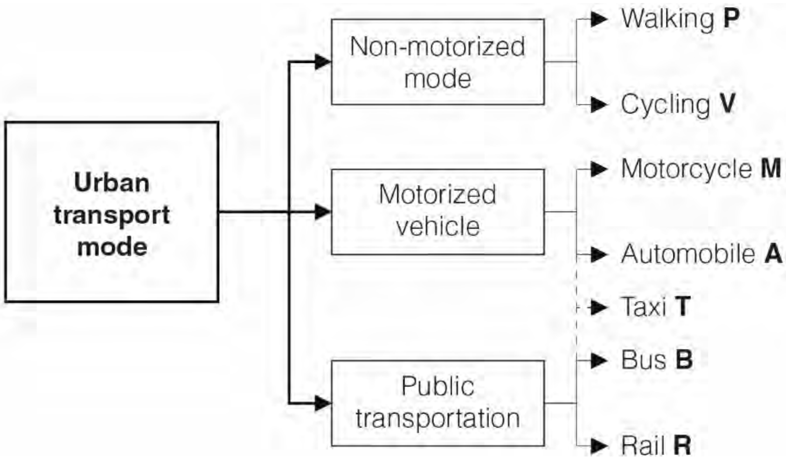


Figure 4.1.6. Urban transportation modes ranking

Source: Created by the author

The sign i symbolizes one of the modes of transportation, such as $i \in \{P, V, M, A, T, B, R\}$.

In addition, there are three other main variables in the cost model:
- the **average travel distance of** the mode: L_i (km);
- the **occupancy rate** t_i (passenger/vehicle), the average number of people in the vehicle of mode (*i*);
- the **average speed** of mode (*i*): i_f (km/hr), the commercial network speed.

Coding the parameters to estimate the total cost of travel can allow us to systematically calculate and compare the relative costs of travel in the city. To this end, we first aim to describe the mutual relationship between these parameters and to define the programming formulas. Although the process of estimating costs from the available data has been simplified, this method of systematically assessing travel costs remains useful for future research.

Note: The unit cost formulas below mark the unit for all formulas in our search, such as dollar value per pkm for example. Currency means the local currency, such as EUR for Europe or JPY for Japan.

4.1.6.2. Private cost model

The total cost of travel can therefore be divided primarily into three categories: private cost (also called user cost), public cost (also called community cost), and external cost (called social cost). The private cost can be considered as directly borne by travellers and employers, and therefore likely to be perceived by travellers. Public and external costs, on the other hand, are more likely to be borne by other actors, such as communities. Depending on the typology of travel costs, we can first define the private cost $C(PV)$ using formula (1):

$C_{PV(Z,i)} = C_{U(Z,i)} + C_{H(Z,I,k)}$; $i \in \{P, V, M, A, T, B, R\}$ (1)

U and H symbolize the user cost and the travel time cost, to which the parameters Z, i and k are assigned. Z defines the geographical attribute, such as city centres, suburbs or peri-urban areas; parameter (k) defines the attribute of the traveller. We will present these parameters more precisely in the following paragraphs.

4.1.6.3. The user cost $C_{U(Z,i)}$

Depending on the definition of the respective characteristics of the cost, the user cost can be divided into two parts: the first is the fixed cost, the second is the variable cost. For the variable user cost, it depends on the travel distance, the vehicle capacity (engine power, vehicle size, etc.) and the urban typology (Z) (city centre, suburban, peri-urban). On the other hand, the fixed user cost does not change when travel parameters change. We can then describe the components of fixed and variable costs below:

- **fixed cost**: purchase or rent of the vehicle, insurance, registration and vehicle tax (vignette, PV registration etc.)

- **variable cost**: maintenance, repairs, fuel, parking lots, tolls, etc.

We can therefore define the user cost by the formula (2):

$C_{U(Z,i)} = (U_{F1+F2+\ldots+FN} + U_{V1+V2+\ldots+VN})_i$; $i \in \{P, V, M, A, T, B, R\}$ (2)

Where (U_F+U_V) is the user cost, U_F the fixed cost and U_V the variable cost of the vehicle per km and per vehicle (money/vkm).
The user cost of the vehicle per km per trip is represented by $(U/t)_i$ with t_i representing the occupancy rate.

The vehicle operating cost per trip is therefore: $((U/t)*L)_i$ (money/travel), where L_i represents the average travel distance.

The process of estimating the user cost is discussed in section 4.3. User cost also includes taxes γ, such as taxes, road traffic fines and vignettes, etc.

4.1.6.4. Time cost model $C_{H(Z,i,k)}$

The cost of time is the most important cost in the total cost of travel for travellers. According to the Litman report, time cost typically accounts for one-quarter of the total cost of PV travel. However, travel time involves many components, time spent in the vehicle, waiting time at the platform, transfer times in interchange hubs, etc. However, we consider only the most important components in order to simplify the cost modelling process.

We can mainly define the cost of time according to the time spent in and out of the vehicle. Therefore, the time spent in the vehicle is called L/S where L is the average travel distance and S is the average speed of the modes we defined at the beginning of this section. It is indeed a network distance and a commercial network speed, and the time spent outside the vehicle is named ∂ including the waiting time t_n, the transfer time t'_n (equals the value of the time in walking), the parking time t''_n and the time of entry to the final destination t'''_n. Moreover, the geographical condition (Z) and the traveller attribute (k) may also affect the cost of travel time except for the different mode of transportation, since the transfer situation (hub) in the centre and in the suburbs is always different, and the various traveller attributes (reason for travel, as leisure or work) actually correspond to different values of time, but we assume that there is a single traveller attribute in our estimation.

Therefore, the total time cost formula can be denoted $C_{H(Z,i,k)}$ as follows.V_E

$$C_{H(Z,i,k)} = ((V_E*\partial) + (L/S*V_I))/L)_i \quad ; i \in \{P, V, M, A, T, B, R\} \ (3)$$

Where:

The value of time outside the vehicle $V_E(i,k)$ (money/hour) means that the value of time depends on the traveller k attribute (reason, income) and mode i of transportation.

The value of time inside the vehicle $V_I(i,k)$ (money/hour)

The average time outside the vehicle $\partial = t_n + t'_n + t''_n + t'''_n$ where t_n, t'_n, t''_n and t'''_n are waiting time, transfer time and parking time and access time to stops (hour)

According to formula (3), we can see the cost of time outside the vehicle: $(V_E * t_n)_i + (V_I * t'_n)_i + (V_E * t''_n)_i$ (money), because the value of the t'_n match time is estimated as the value of the walking time, that's why we mark V_I of walking mode for this part. In addition, the cost of time inside the vehicle is $(L/S^* V_I)_i$ (money).

Therefore, the cost of time per km and per trip is shown by $C_{H(Z,i,k)}$ (money/pkm) and the cost of time per trip is shown by $((V_E{*}\partial) + (L/S{*}V_I))_I$ (money/travel). In addition, more detailed explanations of the figures involved can be found in Section 4.3.

4.1.6.5. Public cost $C_{PB(Z,i)}$

Public cost is mainly considered in the evaluation of transportation operating costs. This cost is borne by the public authorities. In principle, the result of evaluating public cost is always less variable than private and external cost because we theoretically obtain more precise correlative data from local authorities or public transport companies.

Moreover, according to the Litman report, the public cost is only 7% of the total cost for the automotive mode. On the other hand, the proportion of public cost for the public transport mode is certainly higher than for the automobile mode.

Thus, to evaluate public cost, we propose two valuation approaches: one is the accounting approach linked to annual operating and investment flows, and the other is the economic approach linked to the value of the existing capital stock by deducting an annual depreciation cost and adding to the land cost of space consumption[1], see section 4.4.

Apart from the public cost related to operating and capital expenditures, we also need to represent the amount of revenue from specific taxes and parking revenues on PV and on commercial revenues of transit companies in order to partially avoid double counting, we will present the process of estimating the public cost and relative fiscal returns in PT and PT, see section 4.4.

4.1.6.6. External cost model $C_{EN(Z,i)}$

To estimate the external transport costs, we first present the theoretical descriptions in order to indicate the potential parameters in the external costs. Although these external costs are simply estimated on the basis of the data available, it is still necessary to know the essential factors in these costs in order to establish the systematic evaluation of the external cost in future research.

In principle, the external cost[2] is an invisible and unpaid cost for users at the moment. Although there are many kinds of external costs, see figure 4.1.3, we consider the five most important costs: the cost of air pollution, the cost of noise, the cost of the greenhouse effect, the cost of accidents, and the cost of congestion in our research. However, the cost of congestion[3] is a potential cost that is related to the value of time in circulation. On the other hand, it is not relevant here for the

[1] The cost of space consumption is the sum of the space consumed in traffic (CEC) by the use of the road vehicle during or at the end of its daily trips, measured in square meters per hour (m^2/h).

[2] External costs correspond to the monetization of the nuisances produced by the transport system and not internalized in the current market mode. They include costs related to noise, air pollution, congestion, the greenhouse effect, and traffic accidents.

[3] Congestion is defined as the inconvenience that vehicles impose on each other as a result of the relationship between the density of traffic on a route or network and the speed of traffic flow, taking into account capacity. Beyond this approach, the term has many meanings (INFRAS/IWW).

analysis of overall cost, which already includes a valuation of time spent in travel. Moreover, we still show this cost of congestion in the part of external costs in our research in order to compare the importance of congestion in relation to other external costs linked to different modes.

The analysis of external costs has been increasingly discussed over the last ten years or so, but these external costs are still very variable according to international studies. On the other hand, within the framework of sustainable development, we still need to try to add the consideration of these external costs to transport measures. To do so, we aim to assess these sustainability costs in our model, see section 4.5.

4.1.6.7. Air pollution $P_{(i,Z)}$

Air pollution is mainly assessed through its impact on human health. It is therefore directly related to the value of human life. Moreover, air pollution results from the combination of different types of pollution.

According to the definition of INFRAS-IWW (2000), the cost of air pollution can be written by the health of exposed populations and mortality and morbidity at the human scale and also by environmental damage at the natural scale. The general valuation formula for the cost of air pollution is given in a broad sense.

$P(i,Z) = (HD+CL+FD)_{i,Z}$ (money/km/vehicle) (4)

Where $(HD)_i$ is the human damage caused by the mode of transport i in zone z;
$(CL)_i$ is the lost benefit from agriculture caused by transport mode i in zone z; $(FD)_i$ is the damage to forests caused by transport mode i in zone z;

Because of this complexity of assessing the human, agricultural and natural costs of pollution, most studies only ever estimate the cost of air pollution related to human damage.

4.1.6.8. Noise $N_{(Z,i)}$

The cost of noise is evaluated by taking the unit value of the damage suffered by the people disturbed, multiplied by the number of people. After counting the populations subjected to more than 65 dB(x), between 60 and 65 dB(x) and between 55 and 60 dB(x), the unit value is multiplied by the number of inhabitants assumed to be bothered by the total cost of the nuisance (Boiteux, 2001).

$N_P = ½ * VB[0,1\{L_J\text{-}60dB(x)\}+0,1\{L_n\text{-}0,55dB(x)\}]$ (money/inhabitant) (5)

Where N_P is the unit cost of noise per capita per year; VB_i is the base value per year[4] and L_J and L_n are the noise levels in day and night periods. This formula adopted is consistent with the regulations in force for the protection of residents living near new roads: the noise level below which the value

[4] It is recommended 963F in 1994 by the report of Boiteux. p. 252. This value per year corresponds to a sound level of 70 dB(A) during the day and 65 dB(A) at night.

of annoyance is zero is the level corresponding to the regulatory threshold, night-time annoyance and daytime annoyance are distinguished and taken into account with equal weight.

In addition, the noise cost per km per trip depending on the geographical condition can be shown below:

$N_Z = (N_P*(Pop)_z)/\sum_Z(L_i*Nb_i)$ (money/pkm) (6)

Where $(Pop)_z$ is the number of inhabitants in zone z ; $(L_i)_z$ is the average travel distance for mode i in zone z ; $(Nb_i)_z$ means the number of trips per year for mode i in zone z ; $\sum_Z(L_i*Nb_i)$ is the total travel distance for all modes in zone z. In addition, the unit cost per km per vehicle can theoretically be represented by the following formula $N_{(z,i)} = N_z/t_i$ whose sign t_i is the occupancy rate.

4.1.6.9. Greenhouse effect $E_{s(i)}$

The cost related to the greenhouse effect is a global pollution in the world. Therefore, it is rather the same for each area in the city. For this reason, this cost is only differentiated by the mode of transport linked to the different occupancy rate.

To evaluate the cost of the greenhouse effect, we refer to the study by Boiteux (1995) in which the cost of the greenhouse effect can be decided by the energy consumption of fuel, as in equation (8) below:

$E_{s(i)} = C_E(i) * 0.83 * T_{carbon}$ (money/vkm) (7)

Where $C_E(i)$ is the energy consumption in kgoe[5] per mode and per pkm (kg fuel/vkm), T_{carbon} is the carbon tax, the coefficient of 0.83 can be expressed as the transformation from kilos of fuel to kilos of carbon produced in the transport sector.

4.1.6.10. Accidents $A_{(Z,i)}$

The cost of accidents aims to assess the value of human life which can be divided into three categories: the cost of compensation C_I, human capital C_H, willingness to pay or accept C_C.

In addition, we first aim to specify these three categories of accident values $(C_I + C_H + C_C)$; first, the values used, which are generally used to calculate the compensation paid by insurance companies to victims, are based primarily on the direct costs (material and moral) of accidents, which are generally revised to take into account the fact that these benefits only cover insured losses.
Second, for the cost of human capital, it is based on estimates of the losses that society will incur as a result of the death or injury of an individual. Third, willingness to pay or willingness to accept focuses on assessing the satisfactions that the accident deprives the victim and his or her relatives of as a result of the years of life lost.

[5] kgoe : kilogram of oil equivalent

In addition, the total cost of accidents is estimated by multiplying the numbers of fatalities and injuries by the corresponding unit values, plus the assessment of property damage. The key points in the evaluation of accidents are the unit values of human life and injuries and the determination of their internal and external shares. To determine the cost of accidents, we assume that there is only one type of traffic, that all users have the same external and internal cost in the mode of transport i. Thus, the formula for total accident costs can be shown below (Quinet, 2005):

$A_i = (a)_i * Q_i * r(Q)_i$ (money) (8)

Where,

- (a) : is the value of human life.
- Q_i : the flow of mode i in road transport.
- $r(Q)_i$: the risk rate, number of accidents for mode i per unit of flow, which depends on the flow rate.

Therefore, the average unit cost of accidents per vehicle is evaluated as in the following formula: $(A/Q)i = (a+c)*r(Q)$ (money/vkm).

4.1.6.11. Congestion $G_{(Z,i)}$

Congestion is defined as the inconvenience that vehicles impose on each other as a result of the relationship between the density of traffic on a route or network and the speed of traffic flow, taking into account capacity. Beyond this approach, the term has many meanings. Reference is made here to the INFRAS/IWW viewpoint, which relates traffic volume to the value of time and fuel expenditure.

Congestion relief gains are very significant and are simply valued by the time saved by all users in relation to the vehicle x kilometre removed from a congested route. Therefore, the general formula of total cost of congestion by mode and zone according to mode and zone parameters $G_{(i,Z)}$ can be shown below:

$G(i,Z) = q(i,z)[(V_I(i,k)/v(q)_{i,z} + FC(v(q))]$ (money) (9)

Where $V_I(i,k)$ is the time value for mode i, $q(i,k)$ is the traffic volume for mode i per unit time in zone z, $v(q)_{i,z}$ is the average travel speed (kph) for mode i in zone z; $FC(v(q))$ is the fuel cost per speed (ECU/km). That is, the higher congestion cost is caused by the heavier traffic volume associated with low speed and high fuel cost. In addition, the unit cost of congestion per km and per trip according to the different zone and mode of transport is presented below:

$G(i,Z) = q(i,z) / (L_i * Nb_i)_z$ (money/pkm) (10)

Where $(L_i)_z$ is the average travel distance for mode i in zone z; $(Nb_i)_z$ means the number of trips per year for mode i in zone z.

4.1.6.12. Findings

In accordance with the respective introduction of the external costs above, we therefore deduce that the total external cost is below:

$C_{EN(Z,i)} = P_{(i,z)} + N_{(i,z)} + E_{S(i)} + A_{(i,z)} + G_{(i,z)}$ (money/vkm) (11)

According to equation (11) above, $C_{EN(Z,i)}$ is the external cost per km per vehicle, so divide by t (occupancy rate) to get the external cost per km per trip is $(C_{EN}/t)_i$ (money/pkm).

4.1.6.13. Total travel cost model C_i

In accordance with the respective cost descriptions, we can define here that the total travel cost is integrated by the equation below:

$Ci = CPV(Z,i) + CPB(Z,i) - \gamma + CEN(Z,i)$; $i \in \{T, A, M, V, P, R, B\}$ (money/vkm) (12)

Where γ is the public return, including taxation, revenues, to avoid double counting in the total cost of travel. In addition, the total cost per trip $(C/t{*}L)_i$ (money/travel), and the total cost per km per trip $(C/t)_i$ (money/pkm) where t is the occupancy rate and L is the distance (km) travelled.

4.1.6.14. Matching in the total cost model

As a result, in the total cost of travel can be considered the cost of connection or non-connection for intermodal travel.

Total cost of travel without correspondence $(C_{non\text{-}C})_i$

This situation can be assumed if the traveller uses only one mode of transportation from origin to destination, there are no connections in the trip.

a. Total travel cost per trip $(C^T_{non\text{-}C})$

$(C^T_{non\text{-}C})_i = (C/t{*}L)_i$ (money/investment) (13)

b. Total travel cost per km per trip $(C^K_{non\text{-}C})$

$(C^K_{non\text{-}C})_i = (C/t)_i$ (money/pkm) (14)

Total cost of travel with correspondence $(C_{avec\text{-}C})_i$

This travel condition is only carried out by the same mode of transport from origin to destination, but it is still called a special case of intermodal travel, e.g. bus & bus or subway & subway etc.

Therefore, we first define the two parameters before presenting the formula: the average time for O-D: T_C and the proportion between time outside the vehicle and total time: P_T. In fact, the total cost of intermodal travel has more than one cost of time outside the vehicle in relation to the total cost of travel in single mode.

a. Total travel cost per trip C^T_{avec}-C (for one mode)

To estimate the total cost of intermodal travel, this cost is the sum of two parts: one is the cost of travel inside the vehicle (as A in Formula 16) and the other is the cost of travel outside the vehicle (as B). Thus, if only the cost of travel inside the vehicle is considered, the total cost of intermodal travel is exactly the same as the cost of single mode travel. For this, we can see that the cost of travel outside the vehicle is the incremental cost to the total cost of intermodal travel, including the cost of time associated with connecting, waiting, parking, etc., and the cost of travel inside the vehicle is the incremental cost to the total cost of intermodal travel.

$$(C^T_{avec\text{-}C})_i = \sum_{1}^{j} \left\{ \frac{(C_{PV} + C_{PB} + \gamma + C_{EN})}{t} * T_C * (1 - P_T) * S + [V_E * (T_C * P_T) + T_C * (1 - P_T) * V_I] \right\}_i$$

A. Travel cost inside the vehicle

B. Travel cost outside the vehicle

(15)

Where $j \geq 1$ (money/trip)

Here, j is the number of matches, and the sign (T_C * P_T) is the time outside the vehicle for the match, including waiting time, matches and also parking time in our research. However, we first assume here that walking in the station and waiting for the vehicle or parking time have only the time expenditure for travellers, as for the costs of public expenditures (for parking lots, PT stations, pedestrian undergrounds etc.); and externalities (station heating, personal insecurity) are respectively counted in the C_{PB} and C_{EN} articles.

In the above formula, if j is zero, it means that there is no correspondence in the trip, so we can observe that the total cost of trip with correspondence equals the cost of trip without correspondence.

$$(C^T_{avec\text{-}C})_i = (C^T_{non\text{-}C})_i$$

b. Total travel cost per km per trip $C^{K}_{avec\text{-}C}$ (for one mode)

$$(C^{K}_{avec\text{-}C})_i = \frac{1}{L}\sum_{1}^{j}\left\{\frac{(C_{PV} + C_{PB} + \gamma + C_{EN})}{t} * T_C * (1 - P_T) * S + [V_E * (T_C * P_T) + T_C * (1 - P_T) * V_I]\right\}_i$$

A. Travel cost inside the vehicle
B. Travel cost outside the vehicle
(money/pkm) (16)

Where, S is the average speed of the modes and L is the travel distance from origin to destination.

Main hypothesis:

Hypothesis 1: If there is no match in the displacement, then *j* equals zero.

Hypothesis 2: The time spent walking to a transfer in the station should be counted here together with the cost of walking in a section of the journey, e.g. the cost of walking from home to the station etc., when passengers take the bus or subway.

4.1.6.15. Combined mode cost model

Following a description of the total cost of travel with a connection by a mode from origin to destination, this paragraph will incorporate the costs shown for intermodal travel related to the different modes. To do so, we can divide the origin-to-destination trip into three main sections, such as the entry section (before entering the first PT station), the exit section (after leaving the last PT station) and the section between exchanges poles (from the first station to the last station), see the following figure. So, we have to combine the travel costs in relation to the sections to get the total travel cost of the traveller. In addition, we can also present the relative formulas of the total cost per trip and per traveller kilometre.

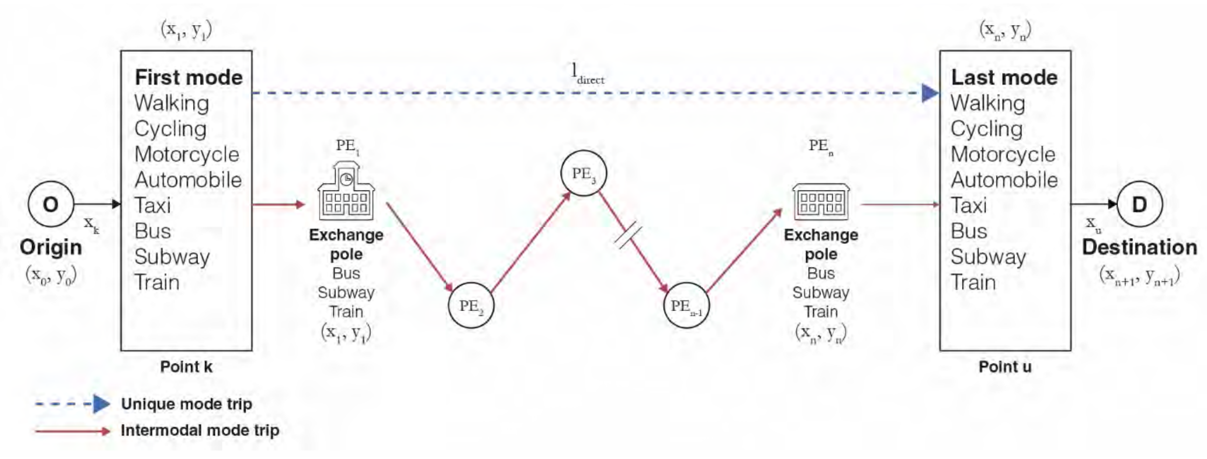


Figure 4.1.7. Intermodal transportation passenger travel

Source: Created by the author

The total combined cost of travel with correspondence

a. Total travel cost per trip (combined modes)

$$CT = \{(C^T{}_{with\text{-}C})_{i=T, A, M, V, P}\}_{enter} + \{(C^T{}_{with\text{-}C})_{i=R, B}\} + \{(C^T{}_{with\text{-}C})_{i=T, A, M, V, P}\}_{exit}$$

A. Before entering exchange pole
B. Inside exchange pole
C. After exiting exchange pole
(money/trip) (17)

b. Total travel cost per km per trip (combined modes)

$$CK = (1/L) * \{[(C^K{}_{avec\text{-}C})_{i=T, A, M, V, P} * l_0]_{enter} + [(C^K{}_{avec\text{-}C})_{i=B, R} * \textstyle\sum_1^{n-1} l_n] + [(C^K{}_{avec\text{-}C})_{i=P, V, MvA, T} * l_n]_{exit}\}$$

(money/pkm) (18)

Where L is the travel distance from origin to destination ($L=\sum_0^n l_n$) et l_0, l_n et $\sum_1^{n-1} l$ is the transport distance for each section in the same trip. Therefore, we can approximately simplify the above formula as follows, if the weighting value for each section is the same.

$$C_K = (1/(2+j)) * \{[(C^K{}_{with}\text{-}C)_{i=T, A, M, V, P, B}]_{enter} + [(C^K{}_{with\text{-}C})_{i=R, B}] + [(C^K{}_{with\text{-}C})_{i=P, V, MvA, T, B}]_{exit}\}$$

A. Before entering exchange pole
B. Inside exchange pole
C. After exiting exchange pole
(money/pkm) (19)

Where $j \geq 1$ (money/pkm)

4.1.6.16. Modelling the cost of intermodal travel

Based on the definitions of costs in travel, the goal here is to integrate these various travel costs in order to establish a general model of the cost of intermodal travel analysis. We can assume that the traveller comes from origin $(x_0;y_0)$ and arrives at destination $(x_{n+1};y_{n+1})$in urban areas.

We also need to consider location and the fundamental attribute of travellers in cost modelling processes, as discussed in the last paragraph. For this purpose, we have provided the correlative decomposed cost modelling formulas for intermodal and non-intermodal travel.

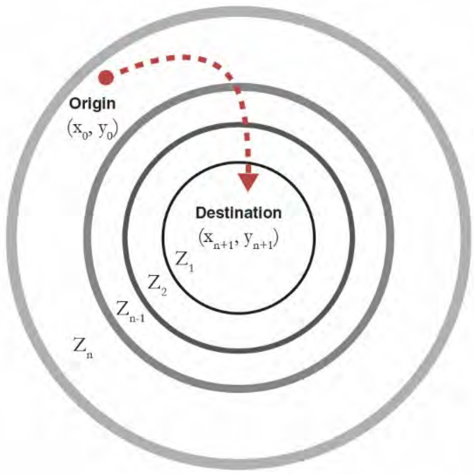


Figure 4.1.8. Origin and destination geographic location

Source: Created by the author

C_U	Unit cost of use per trip	t_n	The time to walk to the correspondence
C_{PB}	Public unit cost per trip	t'_n	Waiting time for correspondence
C_{EN}	External unit cost per trip	C_E	Time value outside the vehicle
S_i	Average speed per mode	l_{direct}	Distance between point k and u
l_0	Distance between the last exchange pole Sn and the point u	l_n	Distance between point k and the first exchange pole S1
Z	Area in the city	C_I	Value of time inside the vehicle
x_k	Walking distance from the origin to the first mode of transport	x_u	Walking distance from the last mode of transportation to the destination

Figure 4.1.9. Introduction of parameters for equations

Source: Created by the author

Mode		Intermodal transport		Non-intermodal transport
		Before PE1 / After PE_n	Intermodal section (PE_1 > PE_n)	Direct O-D
Private cost	1. Usage cost	$C_{1/D} = C_u(Z,i)*(l_0+l_n)$	$C_{1/I} = \sum_{(n=1)^\wedge n} C_U(Z,i)*l_n$	$C_{1/OD} = C_U(Z,i)*L$
	2. Time cost	$C_{2/D} = (x/S_i)*C_{I(i,k)i=P} + ((l_0+l_n)/S_i)*C_{I(i,k)}$	$C_{2/I} = \sum_{(n=1)^\wedge n} ((l_n/S_i)*C_{I(i,k)}+\delta_n*C_{E(i,k)})$	$C_{2/OD} = (x/S_i)*C_{I(i,k)i=P} + ((L)/S_i)*C_{I(i,k)}$
	3. Public cost	$C_{3/D} = C_{PB}(Z,i)*(l_0+l_n)$	$C_{3/I} = \sum_{(n=1)^\wedge n} C_{PB}(Z,i)*l_n$	$C_{3/OD} = C_{PB}(Z,i)*L$
	4. External cost	$C_{4/D} = C_{EN}(Z,i)*(l_0+l_n)$	$C_{4/I} = \sum_{(n=1)^\wedge n} C_{EN}(Z,i)*l_n$	$C_{4/OD} = C_{EN}(Z,i)*L$
	Partial total cost	$C_D = \sum_{(j=1)^\wedge 4} C_{j/D}$	$C_I = \sum_{(j=1)^\wedge 4} C_{j/I}$	$C_{OD} = \sum_{(j=1)^\wedge 4} C_{j/OD}$
	Total	$C_{Total} = C_D + C_I$		$C_{Total} = C_{OD}$

Figure 4.1.10. Decomposition of total travel costs in intermodal and non-intermodal transportation

Source: Created by the author

Note: $x = x_k + x_u$: distance runs from the origin to the first mode and from the last mode to the destination

$\delta_n = t_n+t'_n+t''_n$: time outside the vehicle

$L = l_{direct}$

According to the previous table, we know that the trip from origin to destination uses only one mode of transportation and that is a special case in intermodal travel. In addition, these costs are average costs per mode and per O-D, but may vary considerably depending on the actual trip made.

4.1.7. Diagnostic concept for mode competitiveness and transportation measures

After establishing a total travel cost algorithm (including intermodal and non-intermodal travel), we then aim to present a diagnostic concept related to the competitiveness of modes and transport measures in the areas. Indeed, within the framework of sustainable development, the development of transport modes must take into account the specific characteristics related to the different aspects (users, government, and society) in order to create the maximum social benefit. These specific characteristics can directly determine the relative competitiveness of the modes in the area. That is, the concept of diagnosing mode competitiveness can be based on the coherence of mode development related to these different aspects based on the assessment of travel costs, since mode development must satisfy not only user demand but also government capacity and environmental impact.

According to the definition of the typology of travel costs in the last section, the private cost, which includes the user cost and the cost of time, affects user behaviour; the public cost (known as the government summation) is borne by communities, and the external cost of environmental impact concerns society as a whole, see figure 4.1.11.

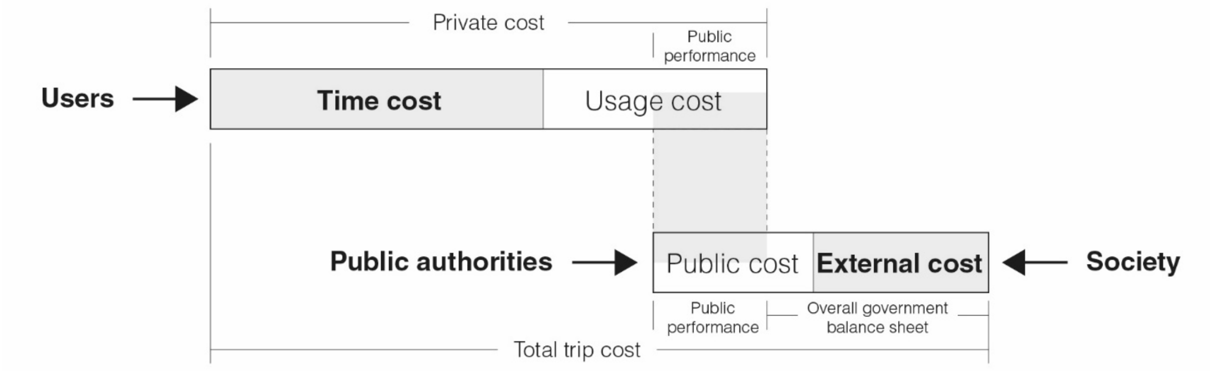


Figure 4.1.11. Travel cost structure

Source: Created by the author

Note: The overall government summation is government expenditure plus external cost minus government revenue.

Next, we can divide this diagnostic model into three dimensions: the individual choice linked to the costs borne by users (the private cost), the public financing budget linked to the actual public expenditure[6] borne by the public authorities, and the environmental impact linked to the costs to society of unemployment. Logically, the total economic cost (including external costs) should be the primary criterion for judgment. However, over the last fifteen years or so (in France and Europe), the policies pursued have been based on this overall cost, which is the same as the benefits that can be obtained from minimizing external costs. Nevertheless, users "keeping control" about their behaviour, and that this is guided by private costs. Nonetheless, the financial strain on public budgets is becoming heavier every day, and this is why we have adopted a three-pronged approach (private, for public authorities, external) to carry out the analyses.

Following the definition of diagnostic model through dimensions, we propose an example in the following figure in order to explain the competitiveness between PV and PT based on these dimensions.

If the development of PT mode can, for example, satisfy the three dimensions related to individual choice, public funding budget and environmental impact (the area "A"), it means that PT development is absolutely coherent and competitive with other modes for different activities (users, public authorities and society).

[6] The balance of income and expenditure constitutes the summation for the public authorities.

Zone A: $C_{PV}(PV) > C_{PV}(PT)$, $C_{PB}(PV) > C_{PB}(PT)$ and $C_{EN}(PV) > C_{EN}(PT)$

In addition, in the areas "B", "C" and "D" if the mode development satisfies only two of the three dimensions, then the total cost of travel should be checked[7] to determine the level of inconsistency. For example, the PT development linked to the area "B" means that it is consistent with the other modes in the dimension linked to individual choice and environmental impact, but inconsistent in the dimension linked to the public funding budget.

Zone B: $C_{PV}(PV) > C_{PV}(PT)$, $C_{EN}(PV) > C_{EN}(PT)$ but $C_{PB}(PV) < C_{PB}(PT)$

In this case, we can implement correlative transportation measures to change the inconsistent situation related to the public funding budget. That is, this model is also suitable to be applied on the diagnosis of the compatibility of transportation measures.

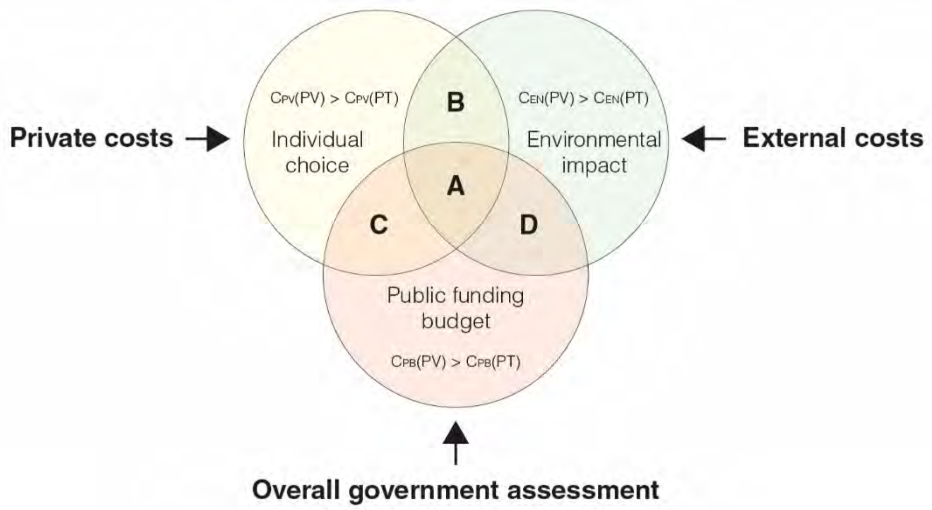


Figure 4.1.12. Cost-based mode development coherence diagram

Source: Created by the author

[7] $C_{Total(Z,i)} = C_{PV(Z,i)} + \{C_{PB} + C_{EN} + \gamma\}_{Z,i}$

In line with the qualitative description of the diagnostic method on the competitiveness of modes, we see that travel cost analysis can answer several questions on transport development in the context of sustainable development through different aspects. For this reason, a model for diagnosing the competitiveness of the modes is proposed that is derived from the assessment of travel costs. The result of the travel cost assessment will be presented together in the travel cost summary. In addition, this result will then be applied in the third part to examine the compatibility of transportation measures.

Overall, a competitive and coherent mode of transport, which depends on geographical conditions, user characteristics, and individual economies, must provide strong user-related services and at the same time respect both the public funding budget of the government and the environmental impact within the framework of sustainable development.

4.2. The cost of travel time

According to the previous definition of travel cost, private cost consists of two main costs: the cost of time and the monetary user cost. It is a direct cost of transport to users. The results of cost evaluation in international studies indicate that the cost of travel time is almost one-third of the overall cost of travel. For this reason, we will present the private cost in two sections, the first section will first specify the cost of travel time, and the second section is intended to indicate the user cost.

Unlike price and other factors, time is absolutely constrained since the traveller cannot increase the time spent on travel to infinity (Golob, 2000; Bhat and Koppelman, 1999). Time savings are one of the major motivations of passengers choosing a mode of transport. This is valued using the concept of the value of time. Moreover, before we begin to define the cost of travel time, we must first know the relationship between the value of time, the evolution of its development and the use of modes, because this knowledge will enable us to make more accurate assumptions and rankings.

4.2.1. The theoretical concept of the value of time

The notion of the value of time is the result of ancient research. In traditional theory, the value of time is constructed by the field of economic analysis. The first reflections on the value of time focused on its scarcity, i.e., the value of time is linked to the relative scarcity of time and money: the consumer, faced with the double constraint of scarcity of time and money, attributes a monetary value to time. The value of time, used to convert user time savings into money, is an essential element in the calculation of the benefits of transport modes. In addition, there are two types of value[8] that are used: revealed or behavioural value, and guardian value. Revealed, or behavioural, value is what users implicitly attribute to their time, and what they reveal through their behaviour. And tutelary value is what the State, in its wisdom, attributes to the time of citizens. A tutelary value has sometimes been used. A consensus has been reached today to use a revealed value.
Research on the value of time can be conceptualized to focus on the marginal utilities of work and leisure time.

[8] According to the GAC report (OEST), it is stated that there are in fact two values of time for transport projects: one revealed by behaviour, used to assess the benefit to users; the other, “tutélaire”, used to calculate the benefit to the state. This second value is calculated from average hourly wages (including related charges), to which a reducing coefficient is assigned according to the reasons for travel; this makes it possible to calculate an average value.

The economist Becker (1965) proposed that the cost of activity should include not only the monetary and resource expenditure, but also include the cost of time spent on that activity, the cost of time here can be called the forgone income, that is, replacing work with another activity during that time. Beesley (1965) used the coefficient on the time variable and the coefficient on relative cost to estimate the value of time. Johnson and Oort (1969) presented the value of time relative to marginal utility as non-zero. Bradly and Gunn (1990) have previously investigated the value of time in relation to mode choice.

In reality, this absolute value of time is never measured, because we only observe choices depending on the alternatives present, and we can only compare the relative disutility of time for different activities. These disutilities differ from the absolute value of time of a term expressing the constrained nature of the activity. If this term is null, it is a pure leisure activity. If this term is non-zero, it represents the value of time lost for this constraining activity, compared to a pure leisure activity, and it is therefore this notion that must be used for valuation. This notion of the value of time is therefore specific to the activity practised.

Research on the value of time in the world is still developing, so there is still no way or theory that we can accept together. Moreover, the value of time can be affected by many factors (e.g., income, age, work time, reason for travel, comfort level, travel distance, safety, etc.). As a result, the value of time results defined in relation to different regions, using local survey data, always show a great deal of difference. However, useful results can also be obtained through comparison and reasonable assumptions.

4.2.2. Literature review of the values of time

As for revealed or stated preferences studies, they are numerous, however their results are still scattered to this day. Nevertheless, it is possible to compare and synthesize the results of these studies to derive broad trends and average values according to the reason for displacement. For this, we can list these few important points after observing these past research studies:

- the proportion of the value of time to income ranges from 10% to 150%, the difference in this proportion is wide, however, most estimates range from 30% to 50% for urban travel;

- the value of time for business travel is the most important. It is followed by the value of time to go to work, then the value of time to return from work to home, and then the value of time to go to a leisure activity. That is, the value of time is influenced by the reason for the trip;

- past research (Beesley, Quarmby, and Lee et al.) has well demonstrated that the relationship between the value of time and income is proportional, that is, the value of time increases with income;

- the value of time in a motor vehicle is higher than in PT according to past studies. Therefore, we can say that the mode of transport and the value of time are dependent on[9] each other. Passengers can choose a mode of transport according to their individual economic capacity in order to gain the most travel time;

- the value of time increases with the duration of the trip.

[9] This correlation can be explained by the fact that motorists have on average the highest incomes, (compared to adolescent children, massive users of public transport, for example), which then refers to people more than to the modes themselves.

Author	Year	Country	Reason	Value of time (% salary)
Beesly	1965	United Kingdom	Work-home	31-49
Becker	1965	United States	Work-home	40
Quarby	1967	United Kingdom	Work-home	20-25
Stopher	1968	United Kingdom	Work-home	21-42
Oort	1969	United States	Work-home	33
Thomas	1970	United States	Inter-city	40-85 ($1,82-3,94/h)
Hoinville	1970	United Kingdom	Work-home	(£0,72/h)
Lee	1971	United Kingdom	Work-home	30
Wabe	1971	United Kingdom	Work-home	43 (£0,6225/h)
Dawson	1972	Ireland	Different itinerary	60-90
Talvitte	1972	United States	Work-home	12-14 inside the vehicle 7 times more outside the vehicle)
Hensher	1973	Australia	Work-home	27
Kraft	1974	United States	Inter-city	38
McDonald's	1975	United States	Work-home	45-78
Ghosh	1975	United Kingdom	Inter-city	73
Guttman	1975	United States	Leisure	63
O'Farrell	1975	Ireland	Work-home	86 inside the vehicle 189 outside the outside
Howe	1976	United Kingdom	Work-home	(PV: £1,36/h) (Bus: £1,11/h)
Hensher	1977	Australia	Work-home	39
Nelson	1977	United States	Work-home	23-45
Hauer	1982	Canada	Work-home	67-101
Edmonds	1982	Japan	Work-home	42-49 ($4,18/h)
Deacon	1985	United States	Leisure	52-254
Hensher	1985	Australia	Work-home	105 ($9,7/h)
Guttman	1986	Israel	Work-home	59
Fowkes	1986	United Kingdom	Work-home	27-59
Hau	1986	United States	Work-home	46
Chui	1987	United States	Inter-city	82
Mohring	1987	Singapore	Work-home	60-129
MVA	1987	United Kingdom	Different mode	(€8,7/h for road transport) (€13,1/h for rail transport)
Suzuki	1989	Japan	Different reason	€17,5-26,8/h
Sheman	1990	Canada	Work-home	93-170
Bradley	1990	The Netherlands	Different mode	$3,9-9,7/h
NEI	1990	The Netherlands	Different reason	€17,9/h (professional pattern) €4,5/h (non-professional pattern)
Wardman	1998	United Kingdom	Work-home Leisure	£3,24/h £2,58/h
Hensher	2001	New Zealand	- - -	$5,94/h
Jiang	2003	Japan	Work-home	$16,12/h (women) $16,62/h (men)
Mackie	2003	United Kingdom	Work-home Income level <£17,500 £17,500-35,000 >£35,000	£3.96/h - - - £2.16/h £3,54/h £5,16/h
Jara-Diaz	2003	Chile	Leisure	$0,93-1,3/h

Figure 4.2.1. Values of time proposed by the international literature since 1965

Source: Created by the author

In addition, there are many EU-funded studies on the value of time. Thus, the program "UNITE" proposed the value of time €21/h/person for road transport (1998/business) and €4/h/person (leisure). The HEATCO study recommended a similar value of time based on the vehicle, for example, the value of time is €8,48 to €10,89/h for commuting to work. In addition, the time values that have just been studied apply to the evaluation of various physical phenomena, which must be analysed mode by mode. The study of the value of time proposed by HEATCO aimed at analysing the value of time according to the parameters of country, mode of transport, reason for travel and travel distance. Therefore, the value of time is presented in the following table according to mode of transport and reason for travel for the 25 European countries.

Sector / purpose	Unit	PV / Railway	Bus
Business	€2000/passenger.h	23,82	19,11
Work (short distance)		8,48	6,1
Work (long distance)		10,89	7,83
Other (short distance)		7,11	5,11
Other (long distance)		9,13	6,56

Figure 4.2.2. Recommended time values, European average

Source: HEATCO, 2011

Example of the values of time in France

The time values of the Ministry of Equipment are regularly updated. The latest ones are given by the Boiteux report (2001). It proposes a value of time in urban areas varying according to the reasons from 42% of the gross salary or €5.2 1998/h for non-work-related trips to 85% of the gross salary or €10.5 1998/h for work related trips, with an average of 59% of the gross salary or €7.2 1998/h for all reasons. For Ile-de-France, taking into account the higher salaries, the values proposed are also higher, with an average of €8.8 per hour for all reasons. In addition, several studies conducted by economists have analysed the distribution of households in France according to their income. The working hypothesis is that, on average, people have found a balance between housing and transport costs. The conclusion of these studies is that people seem to consider that the cost of an hour spent in transport is equivalent to about 59% of an hour's gross wage, regardless of socioeconomic level (Science-décision, 2006).

Author	Geographical area	Year	Value (€)	Remarks (value/vehicle)
INRETS	Ile-de-France	1988	9,15	Personal motive
			10,67	Home-work motive
			28,2	Professional motive
CETUR	Marseille and Grenoble	1993	4,57 to 9,15	Variable according to the pattern
SNCF	France	1989	7,77	2nd class users
			19,82	1st class users
Matisse	France	1988	10,82	Passenger car
			9,6	Train 2nd class
			28,66	Train 1st class
Palma	Ile-de-France	2001	9,87	PV
			11,8	PT

Figure 4.2.3. Hourly values of time in France

Source: Boiteux, 2001

In our research, we refer to the values of time proposed by Papon after the national survey in France related to the modes and incomes of individuals and to estimate the cost of time in Ile-de-France. In fact, the value of average time in Ile-de-France is theoretically higher than that in France as a whole, thanks to the higher level of income in Ile-de-France. For this, we can use Papon's proposed values of time in France by multiplying an income coefficient (1.25) between Ile-de-France and the whole of France according to the annual income statistics published by INSEE. On the following table is clearly indicated the value of time in relation to the modes of transport related to the level of income in Ile-de-France.

	Income index	Value of time in France (€)	Value of time in Ile-de-France
Moped	0,72	5,30	6,60
Bicycle	0,83	6,10	7,70
Walk	0,88	6,50	8,10
PV passenger	0,93	6,90	8,60
PV driver	1,09	8,00	10,00
PT	1,00	7,30	9,20
TOTAL	1,00	7,40	9,20

Figure 4.2.4. Time value according to modes in France

Source: Papon, 1999

Note: The national average wage per hour is €12,7 (2000) per inhabitant.

Following figure 4.2.4, we can observe that the time values of non-motorized and motorcycle modes are relatively lower among the modes, because their average income is relatively lower.

4.2.3. Value of time in/out of the vehicle

The travel time is not always uniform, on the contrary, it comprises several defined components, such as travel time, waiting time, walking time, connection time etc. The travel time is a component of the travel time on which the search is more complete than on the other components in the travel time. The value of time outside the vehicle is always higher than the value of time inside the vehicle according to past international research.

On the other hand, the time inside the transit vehicle is almost stable, barring accidents, and is a factor that will not change much in the future, because the reduction of time spent in transit must depend on the progress of mechanical technology today. Therefore, most research has begun to focus on off-vehicle travel time in recent years. To encourage the use of PT, we aim to not only analyse the value of time in the vehicle, but we also need to consider the value of time outside the vehicle.

In addition, the fundamental theory of the value of time in/out of the vehicle is also based on classical economic theory. Jara-Diaz (1991) induced the relationship between the value of time in the vehicle, the value of waiting time, the value of walking time and income. Liu (2006) generalised this approach to establish a relationship between the value of time in/out of the vehicle and income[10].

[10] The value of time in the vehicle is $(\partial U_{nj}/\partial t_{ij})/(\partial U_{nj}/\partial_{cj}) = (\beta_2/\beta_1)*I_n$, where t_{ij} is the travel time in the vehicle; in addition β_1 and β_2 are the coefficients for the transport/revenue cost and the travel time in the vehicle. I_n is the

The main research conducted on the evaluation of out-of-vehicle travel time includes waiting time, walking time, and transfer time in the transit mode. In general, the value of waiting time and walking time is perceived as negative time, except for very long trips. It is estimated to be about 1.5 to 2.3 times the value of time spent in the vehicle.

We first present the results obtained from research on the value of time outside the vehicle.

The earliest research, Quarmly (1967), has already shown that the values for waiting and walking time are at least 2 and 3 times higher than the time spent in the vehicle. Following Quarmly's research, Davies and Roger (1973) proposed that the value of walking time should be 2.4 times greater than the value of time in the vehicle, and the value of waiting time should be 2.7 times greater.

In addition, Daly and Zachary (1975) found that the values of walking and waiting time are estimated to be 1.6 and 2.6 times the value of time inside the vehicle compared to the bus and passenger car, respectively. In 1977, Daly and Zachary again proposed values for walking and waiting time of 0.9 and 3.5 times the value of time in the vehicle compared to transit.

Bruzelius (1979) indicated that the value of the time spent walking and waiting is always evaluated 2 to 3 times more than the value of the time spent inside the vehicle.

TRRL (1980) showed that the value of the average walking time is estimated to be twice as much as the value of the time spent in the vehicle and the value of the waiting time is about 3 times as much as the time spent inside the vehicle.

MVA et al (1987), recommended a value for waiting and walking time of 2 times the time spent in the vehicle.

Steer Davies Gleave (1997), indicated that the value of walking time is always estimated to be about 1.8 to 2.4 times more than travel time (the time spent in the vehicle). Therefore, the value of recommended average walking time is simply 2 times more than the travel time, and the value of waiting time is given with the maximum being 4.5 times more than the travel time in this article, so the value of recommended average waiting time is about 3 times more than the travel time.

Wardman (2001) found that the values for walking, waiting and matching time averaged 1.66 (± 0.12), 1.47 (± 0.18) and 0.80 (± 0.08) more than the value for time spent in the vehicle.

The first national research in Germany (Gunn and Rohr, 1996) estimated that the values of walking time and the value of public transport transfer time for the three reasons work-home, business and other are 1.0, 1.6 and 1.3 (the value of walking time for the three reasons) times the value of time spent inside the vehicle and 2.1, 1.6 and 1.6 (the value of transfer time for the three reasons) times the value of time spent inside the vehicle, respectively.

In the Netherlands, Lange (Long Distance Transport Model) reported a value for walking time and waiting time weighted 1.9 times more than travel time (MuConsult, 1993). In the multimodal mode in Belgium, the value of waiting time is weighted 165% with respect to travel time, the value of walking time is also weighted 150% with respect to travel time, and the value of transfer time is estimated to be about 2 to 15 minutes, depending on transfer characteristics (Walle S. V., 2006).

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income for the passenger n. The value of time outside the vehicle is $(\partial U_{nj}/\partial t_{oj})/(\partial U_{nj}/\partial_{cj}) = (\beta_3/\beta_1)*In$ where t_{oj} is the travel time n outside the vehicle; β_3 is its coefficient.

Time outside the vehicle in public transportation

Beyond the proportion between the value of time outside the vehicle and inside the vehicle, there is research that has given measured figures for time outside the vehicle on PT.

Wardman (2001), approximately analysed the time of correspondence which includes waiting and walking time, the time is estimated to be approximately 18 minutes. Indeed, the estimated time to transfer is 3.5 minutes at London Underground (LT, 1995). However, 18 minutes of connecting time is estimated by passengers connecting at the train station.

Empirical research in the UK points out that waiting time at the bus station is 3-4 minutes. Waiting time at the subway station is 5.4 minutes (Hine et al. 2001).

Krygsman (2004), reported in the Netherlands that the arrival distance to the station on foot and by bicycle is 0.55km and 1.8km, and the exit distance from the station to the destination on foot and by bicycle is 0.6km and 2.4km. At the same time, it indicates that the average time to arrive at the train station, i.e. from origin to station, walking and cycling is 8.6 minutes and 10.1 minutes, and the average time to leave the train station, from station to destination, walking and cycling is 9.3 minutes and 12.5 minutes. However, for the average time to get to and from the subway, bus or streetcar station on foot is 5.9 minutes, because few passengers ride bicycles to and from the station. Therefore, he deduced that the average time of arrival to the train station is 1.5 times more than the time of arrival to the subway, bus and streetcar station, and the time of exit from the train station is 1.6 times more than the time of exit from the subway, bus and streetcar station.

O'Sullivan and Morrall (1996) proposed that the arrival distance to the train station should be twice as long as the arrival distance to the bus station. All this work shows the importance of these times and the value that users place on them.

4.2.4. Mode travel time

As for the travel time of the modes, we will first present it according to the different modes (walking, cycling, motorcycle, car, cab, bus and metro) compared to different cities. Here we collect national and local survey data and research reports in studied areas. However, we still need to make some assumptions in order to establish a reasonable platform for international comparison.

4.2.4.1. Pedestrian speed and time

Khisty (1993) indicated that the maximum walking distance is 400 m in North America. Moreover, he has already deduced a simple relationship between speed, distance and travel time for developed and developing countries.

For developed countries:

$d=0.043v^{1.42}$

$T=6.6d^{0.3}$

Where T is travel time (minutes), d is travel distance (km) and v is walking speed (km/h).

For example, if the average speed is assumed to be 4km/h in developed countries, the travel time is 4.64 minutes and the travel distance is 0.308km based on the above formulas.

For developing countries:
$d=0.22v^{1.48}$
$T=19.74d^{0.36}$

Therefore, he proposed that the maximum walking distance in developed countries should be 0.4km and 2km for developing countries. In addition, the maximum distance for cycling in developed countries is 1.5km and 9km for developing countries.

Assuming the average walking speed is 4km/h in developing countries, the travel time is 23.95 minutes and the travel distance is 1.71km.

	Developed countries			**Developing countries**		
	Speed (km/h)	**Distance** (km)	**Time** (m)	**Speed** (km/h)	**Distance** (km)	**Time** (m)
Walking	4,0	0,3	5	4,0	1,7	23

Figure 4.2.5. Speed, distance and time in developed and developing countries

Source: Khisty,1993

Virkler (1998) developed a methodology for predicting pedestrian travel times along urban arterial roads and compared the results with measurements in downtown Brisbane (Australia). The modelled average speed was 3,97km/h and the measured speed was 4,01km/h. Carré & Julien (2000) finely analysed the daily walking sequences of 51 subjects in Ile-de-France. Their average walking speed was 4,7km/h.

The 1993-1994 national survey on transport and communication (Papon, 1997) gives an average speed of 3.6km/h for weekday walking trips made less than 80km from home by people aged six and over living in metropolitan France.

In addition, when analysing transfer time at the transit station, pedestrian speed is an important factor in relation to various passenger characteristics. For example, males walk faster than females, and average walking speed depends on age. Crowd density can influence walking speed, such as at rush hour at the station, walking speed is always slow because the crowd density is high. Mitchell D. H. (2001) indicated that when the crowd density reaches 5 persons/m², it is assumed that the movement comes to a complete stop.

Trengenza (1976) presented curves based on walking speed and crowd density using survey data. Yuhaski and Smith (1989) developed a linear curve to simulate the relationship between walking speed and aisle crowd density.

In Ile-de-France, we can refer to the 2001-2002 global transportation survey data, as they did indicate that the average walking time is 14m, the average walking distance is 0,6km and the average walking speed is 4km/h in Ile-de-France.

4.2.4.2. Cyclists' speed and time

Allen et al. (1998) conducted an excellent review of free vehicle speeds of cyclists. In the United States, average speeds of 19km/h can be observed on bicycle lanes, and between 17,7km/h and 20,1km/h on bicycle lanes. The Transportation and Communications Survey (1993-1994) gives an average door-to-door bicycle travel speed of 9.7km/h for the whole of France, a value to be taken with caution given the rounding to the nearest 5 minutes of travel time by respondents, with a low average travel time of 14 minutes (Papon, 1999).

	Developed countries			Developing countries		
	Speed (km/h)	**Distance** (km)	**Time** (m)	**Speed** (km/h)	**Distance** (km)	**Time** (m)
Bicycle	12,0	1,5	7,5	12,0	9,0	45,0

Figure 4.2.6. Speed, distance and time in developed and developing countries

Source: Khisty, 1993

<u>In Ile-de-France</u>
According to the Vélib' report after 18 months of operation (Lefebvre, 2009)[11], it indicates that the average distance of a trip is 3km and the average speed of a trip is only about 8km/h.

<u>Yokohama</u>
The speed of the bicycle in developed countries is 12km/h and the average distance is 1,5km (Khisty, 1993). In addition, the travel time outside the vehicle for the bicycle mode is 3,07 minutes with 1,85m for walking and 1,22m for parking (Lee, 1997).

Walking and cycling are two modes often considered free: yet they have monetary costs, borne by their users. However, because of their low speed, they mostly have time costs. The value of this time depends closely on the degree of perceived discomfort or pleasure experienced while using these modes, and is therefore delicate. (Papon 2002)

[11] Published in the Society of Automotive Engineers Conference (March, 2009)

4.2.4.3. Motorcycle speed and time

In general, motorcycle travel time can be divided into two main parts: travel time inside the vehicle and travel time outside the vehicle. The travel time inside the vehicle can be calculated by the travel distance and operating speed of the vehicle. For time outside the vehicle, it consists in the general sense of parking time and travel time, i.e. the time from the original motorcycle place to the motorcycle place and from the motorcycle place to the destination.

However, the overall transportation survey in 2011-2012 in Ile-de-France did not separate travel time from travel time outside the vehicle, because the definition of travel time in this survey is marked from the departure and arrival times of each trip. These are door-to-door travel times, including the time to return to the means of transport, and the time to walk from the last means of transport to the place of arrival of the trip. That is to say, the time outside the vehicle is included in the average travel time by motorcycle in Ile-de-France.

For this reason, the cost of time for motorized vehicles in Ile-de-France may be underestimated a little, because only a general value of time is considered. We present below the correlative figures for cities based on local survey data.

	Article	**Ile-de-France**	**Yokohama**
Inside the vehicle	Average distance per trip (km)	9.1 (1)	11,87
	Average traffic speed (km/h)	22.5 (2)	20
	Time in the vehicle (minutes)	24.5	35,6
Outside the vehicle	Average walking time (minutes)	-	-
	Average parking time (minutes)	-	-
	Time outside the vehicle (minutes)	-	2
Average travel speed for users (km/h)		22,5	18,9

Figure 4.2.7. Motorcycle travel times in Ile-de-France and Yokohama

Source: EGT, 2004; MLIT, 2013

Notes : 1. The average travel distance is a distance as the crow flies.
2. The average speed of motorized 2-wheelers in Ile-de-France is estimated by the distance as the crow flies and the average travel time. In addition, the time outside the vehicle is counted in the time inside the vehicle.

4.2.4.4. Speed and time of cars

For PV travel time, we can also divide it into two parts: travel time in the vehicle and travel time outside the vehicle, including parking time. In addition, the time outside the vehicle includes not only the parking time, but also the travel time from origin to vehicle and from vehicle to destination. In addition, in Ile-de-France, we can indicate the respective travel time related to geographical condition based on local survey data in 2001.

Article		Ile-de-France			Yokohama
		Paris	PC	GC	
In the vehicle	Average distance per trip (km)	6.3*	5.3	7.2	20
	Average traffic speed (km/h)	13.5	13.6	20.4	27,6
	Time in the vehicle (minutes)	28.2	22.8	21.2	43,48
Out of vehicle	Average walking time (minutes)	-	-	-	-
	Average parking time (minutes)	-	-	-	-
	Time outside the vehicle (minutes)	-	-	-	-
Average travel speed for users (km/h)		13.5	13.6	20.4	22,4

Figure 4.2.8. Private vehicle travel times

Source: EGT, 2004; MLIT, 2013

Note: The average travel distance is a distance as the crow flies. In Ile-de-France, time outside the vehicle is counted as time inside the vehicle.

PC: Petite couronne (small crown), close suburbs around Paris

GC: Grande couronne (great crown), large suburbs around Paris

4.2.4.5. Speed and time of taxis

In Ile-de-France, we first use the results of the Paris taxi travel survey. The results are established on a sample of 4350 taxis for the average duration of a trip between 7am and 9pm on a working day. More than 190,000 journeys per day, i.e. 350,000 people are transported daily in the Paris taxi pick-up area. On average, 55,000 kilometres per year travelled by each cab. In addition, we can see that the average speed of a taxi is lower than that of a car, because taxis operate a lot in Paris (low speed), and the average speed of a PV actually includes a lot of trips to the outskirts.

Article		Ile-de-France	Yokohama
In the vehicle	Average distance per trip (km)	4,76	4,45
	Average traffic speed (km/h)	12,00	21,28
	Time in the vehicle (minutes)	25,40	12,60
Out of vehicle	Average waiting time (minutes)	-	2,18
	Time outside the vehicle (minutes)	-	2,20
Average travel speed for users (km/h)		12,00	18,00

Figure 4.2.9. Taxi travel times in the two areas

Source: Paris City Hall, 2006; MLIT, 2013

Note: 1. The average travel distance is a distance as the crow flies.

2. The taxi waiting time is here assumed that the traveller does not use the tele-taxi by hailing the taxi on the street.

4.2.4.6. Bus speed and times

Ile-de-France

Article		Ile-de-France	
		Paris	Suburbs
In the vehicle	Average distance per trip (km)	3,00	5,70
	Commercial speed (km/h)	12,90	18,00
	Time in the vehicle (minutes)	13,95	19,00
Out of vehicle	Average walking time (minutes)	3,75	5,25
	Waiting time (minutes)	3,00	5,00
	Time outside the vehicle (minutes)	6,75	10,25
Average travel speed for users (km/h)		8,70	11,70

Figure 4.2.10. Bus travel time in Ile-de-France

Source: RATP, 2003; STIF, 2005

It is known that the speed of buses is low due to the fact that the performance of buses is absolutely lower than that of rail, in particular the bus running in the middle of cities has a lower hourly flow and a lower speed (a minimum interval of 6 to 8 minutes and a speed of 10 to 15km/h). Similarly, the average commercial speed of buses is between 15 and 20km/h compared to the subway speed of 20 to 35km/h, and the minimum bus interval is between 3 to 5 minutes compared to 1.5 to 3 minutes for the subway (Science & décision, 2006). In addition, the gap between bus stations is shorter than for other public transport modes, i.e., bus travel time is theoretically higher than for other public transport modes within the same travel distance because of the relatively low average speed.

Yokohama

Article		Yokohama
In the vehicle	Average distance per trip (km)	7,90
	Commercial speed (km/h)	22,88
	Time in the vehicle (minutes)	20,72
Out of vehicle	Average walking time (minutes)	7,58
	Waiting time (minutes)	8,88
	Time outside the vehicle (minutes)	16,46
Average travel speed for users (km/h)		12,70

Figure 4.2.11. Bus travel time in Yokohama

Source: MLIT, 2013

4.2.4.7. Speed and time of subways

Article		Ile-de-France (subway)	Ile-de-France			Yokohama
			Paris	PC	GC	
In the vehicle	Average distance per	5,00	8,70	5,00	17,70	10,14
	Commercial speed	27,00	41,00	27,00	47,00	25,00
	Time in the vehicle	10,90	12,70	10,90	22,50	30,00
Out of vehicle	Average walking time	5,00	5,50	5,00	10,00	8,00
	Waiting time (minutes)	3,00	5,00	3,00	15,00	4,00
	Time outside the vehicle	8,00	10,50	8,00	25,00	12,00
Average travel speed for users (km/h)		15,84	22,46	15,84	23,34	15,00

Figure 4.2.12. Rail travel times

Source: EGT, 2004; STIF, 2005; MLIT, 2013

Moreover, the hypotheses are drawn from the work of Margail in 1993, with the feeder/spreading distances of 250, 350 and 500 m for a trip in Paris, in the inner suburbs and outer suburbs respectively. Waiting times for RER are estimated at 5, 10 and 15 minutes respectively for the three zones proposed by F. Margail, 1993. Moreover, according to data from RATP in 2004, the average interval between lines A and B is 5 minutes in the Paris zone (a 5-minute interval corresponds to a wait of 2.5 minutes), but lines A and B are still more frequent than the other lines. For this reason, the estimate of the average waiting time proposed by Margail is still reasonable in our study. Distance as the crow flies. This average travel speed is estimated by the travel distance and total travel time, including time in the vehicle and time outside the vehicle.

4.2.4.8. Findings

In the tables above, the average speed shown in Ile-de-France is the average speed door-to-door and as the crow flies, thus including terminal times and without taking into account detours, whereas in Yokohama, the average speed is rather the only commercial speed. This is the reason why we can see that the average travel distance of the modes in Ile-de-France is shorter than that in Yokohama.

Following the description of the specific characteristics related to the travel time of the modes, we aim to observe the average speed of vehicles in order to obtain the two points: one is the quality of service of public transport and the other is the fluidity of motorized vehicles.

First of all, we multiplied a coefficient 1.3 (with a distance/range factor) for the average speed of travel in PV in Ile-de-France, as they are estimated by the distance as the crow flies. For the quality of service of public transport (rather bus and metro), they have almost the same level of service quality related to average speed, including time inside the vehicle and time outside the vehicle. As for the fluidity of motorized vehicles, PV has the same level of road fluidity related to average speed. However, in Ile-de-France, the average speed of motorcycles is higher than in Yokohama, because motorcycles in Ile-de-France can travel on expressways and the speed limit is relatively higher. In other words, motorcycles in Ile-de-France also have a good condition relative to the potential market to be developed according to the aspect of time efficiency of travel, especially to replace some PV trips in the city. It pays for this advantage in insecurity. Overall, individual vehicles are faster than public transport, if only average speeds are considered.

Speed (km/h)		Ile-de-France	Yokohama
PV	Motorcycle	29.2	18,9
	Car	23.5 (1)	22,4
PT	Bus	10.8 (2)	10,5
	Subway	15.8	15
	RER	23.0	-

Figure 4.2.13. Comparison of average speed in private vehicles and public transportation

Source: Created by the author

Note: 1. The average speed is 17.5 in Paris, 17.7 in PC and 26.5 in GC.
2. The average speed is 8.7 in Paris and 11.7 in the suburbs.

4.2.5. Comparison of time costs

We can make an assumption about the value of time and calculate the cost of time by mode based on the different value of time and mobility characteristics.

Figure 4.2.14 and 4.2.15 provide estimates of time costs per pkm based on the correlative parameters of travel time and value of time for the modes in Ile-de-France and Yokohama city. In addition, for Ile-de-France, an estimate by type of link is also provided using the different time value by mode (e.g. the time value is €10/h for PV, €6,6/h for motorcycle and €9,2/h for PT. Individual modes appear on average better than public transport, but with different speeds and distances depending on the territory and the type of mode (motorcycle or car, bus, or rail). In addition, these data on speed and distance per link and per mode in Ile-de-France will be used to analyse the disaggregated approach in the synthesis of travel costs.

Mode	Automobile			Public transportation			Motorcycle		
	Speed (km/h)	Distance (km)	Cost (€/pkm)	Speed (km/h)	Distance (km)	Cost (€/pkm)	Speed (km/h)	Distance (km)	Cost (€/pkm)
Paris-Paris	7,4	3	1,35	6,6	3,49	1,39	10,4	3,03	0,63
PC-PC	12,6	4,48	0,79	10,6	7,95	0,87	19,9	7,3	0,33
GC-GC	20,7	6,39	0,48	14	11,23	0,66	19	6,77	0,35
Paris-PC	12,8	7,71	0,78	11,3	9,14	0,81	21	9,21	0,31
Paris-GC	24,9	22,12	0,4	21,6	25,26	0,43	25,9	23,33	0,18
PC-GC	23,2	15,32	0,43	19,3	21,44	0,48	30	15,59	0,22

Figure 4.2.14. Cost of travel time by travel link in Ile-de-France

Source: EGT, 2011

Article		Average trip distance (km)	Average speed (km/h)	Value of time inside the vehicle (€/h)	Time outside the vehicle (m)	Time cost per pkm (€/pkm)
Walking		0,60	2,80	8,10	-	2,89
Bicycle		2,90	8,00	7,70	-	0,96
Motorcycle		9,10	22,50	6,60	-	0,29
Automobile	Paris	6,30	13,50	10,00	-	0,74
	PC	5,30	15,60	10,00	-	0,64
	GC	7,20	20,40	10,00	-	0,48
Taxi		4,76	12,00	10,00	-	0,83
Bus	Paris	3,00	12,90	9,20	6,75	1,13
	Suburbs	5,70	18,00	9,20	10,25	0,92
PT (subway)		5,00	27,40	9,20	8,30	0,83
PT (RER)	Paris	8,70	41,00	9,20	10,50	0,60
	PC	10,20	43,00	9,20	16,00	0,69
	GC	17,70	45,00	9,20	25,00	0,63

Figure 4.2.15. Cost of travel in Ile-de-France

Source: Estimation by the author from EGT, 2011; STIF, 2015; RATP, 2017; SNCF, 2017

Article	Average trip distance (km)	Average speed (km/h)	Cost inside the vehicle (¥/h)	Time outside the vehicle (m)	Time cost per pkm (¥/pkm)
Walking	0,84	4	968	-	242
Bicycle	3,9	12	911	-	76
Motorcycle	11,87	18,9	795	-	42
Automobile	20	22,4	1150	-	51
Taxi	9,1	20	1150	5	58
Bus	9,78	10,5	980	9	93
Railway	10,14	15	980	11	65

Figure 4.2.16. Cost of travel in Kanagawa prefecture

Source: Estimation by the author from MLIT, 2013; NPA, 2017

4.2.6. Summary on the cost of time

Travel costs, including the cost inside and outside the vehicle, are calculated by multiplying the product of the travel time inside and outside the vehicle weighted by the value of time inside and outside the vehicle. We repeat here the two lines on the estimated time cost per trip and per pkm, in order to compare the unit time cost related to the modes of transport.

Travel costs			Cost per trip (€)	Cost per km (€)
Non-motorized modes	Walking		1,73	2,89
	Bicycle		2,78	0,96
Motorized modes	Motorcycle		2,64	0,29
	Automobile	Paris	4,66	0,74
		PC	3,89	0,64
		GC	3,52	0,49
Public transportation	Paris	Paris	3,69	1,13
		Suburbs	5,24	0,92
	Subway		4,15	0,83
	RER	Paris	5,22	0,60
		PC	6,83	0,69
		GC	10,40	0,63

Figure 4.2.17. Cost of time per pkm and travel in Ile-de-France

Source: Estimation by the author from EGT, 2011; STIF, 2015; RATP, 2017; SNCF, 2017

Note: Suburbs includes PC and GC in Ile-de-France

Travel costs		Cost per trip (¥)	Cost per km (¥)
Non-motorized modes	Walking	203	340
	Bicycle	515	132
Motorized modes	Motorcycle	499	55
	Automobile	1020	82
	Taxi	1138	125
Public transportation	Bus	910	140
	Railway	913	90

Figure 4.2.18. Cost of time per pkm and travel in Kanagawa prefecture

Source: Estimation by the author from MLIT, 2013; NPA, 2017

We will note two points that show a particular:

- the cost of time on a motorcycle is little different from that of a PV in Yokohama, it is not PV that makes this mode successful;
- the time costs of PV and public transport are little different in Paris and very different in Ile-de-France.

4.2.7. Advantages and disadvantages according to cost of time

Following the estimation of the cost of travel time per pkm and mode, we first aim to find the relationship between modal split and the cost of travel time in order to show the importance of time in the modal choice of passengers.

According to figures 4.2.19, we can observe that there is quite a different modal split situation. In Ile-de-France, PV is the most important transport mode in the city (44%), while it's only the second most important in Yokohama (23%) behind railway (34%).

For this, we can make a hypothesis before comparing the modal split and the cost of the respective travel time in the city:

- the mode of transportation, which is more attractive, has the cost of travel time more economical;
- otherwise, it is the monetary user cost that decides passenger behaviour for the modal choice of transport.

Region	Non-motorized (%)		Motorized transportation (%)			PT (%)	
	Walking	Bicycle	Motorcycle	Car	Taxi	Bus	Railway
Ile-de-France	31	3,1	2,1	43,9	0,5	6,7	12,7
Yokohama	26	8	3	23	-	6	34
Tokyo 23 wards	23	14	1	11	-	3	48
Tokyo prefecture	23	19	2	26	-	3	27
Kawasaki	26	16	3	18	-	4	34
Saitama	22	20	2	28	-	2	26
Chiba	22	13	2	36	-	3	24
Major japanese cities	22	14	2	29	-	3	30

Figure 4.2.19. Urban transportation modal shares in Ile-de-France and Yokohama

Source: EGT, 2011; DREIF, 2011; Yokohama city, 2019

In this logic, we can see the relative attraction between the modes.
In general, motorized vehicles are relatively the most economical mode in terms of the cost of time per pkm.

According to figure 4.2.20, we can first observe a phenomenon of modes in Ile-de-France: the cost of time per pkm for the use of motorized vehicles (car and motorcycle) is more economical than for the use of public transport and non-motorized modes, in particular the cost of time for the motorcycle is the most economical.

Although the motorcycle mode has the relative advantage related to the cost of travel time, the modal split for motorcycle use is still low (2%). In this logic, the development of motorcycle use also seems to be a potential way to replace some PV use in Ile-de-France. On the other hand, we must also reflect on this measure linked to the development of motorcycles before analysing external costs, since motorcycle use seems to be more negative depending on the aspect of externality (see the results of studies: Litman, IWW/INFRA etc.). In fact, there are two weak points to encourage the use of motorcycles: one is safety, road accidents related to motorcycle use are normally higher than those related to PV use. For this reason, the external accident cost for motorcycle use is relatively much higher than for other modes. The other is the road management difficulty associated with the separate lane and parking.

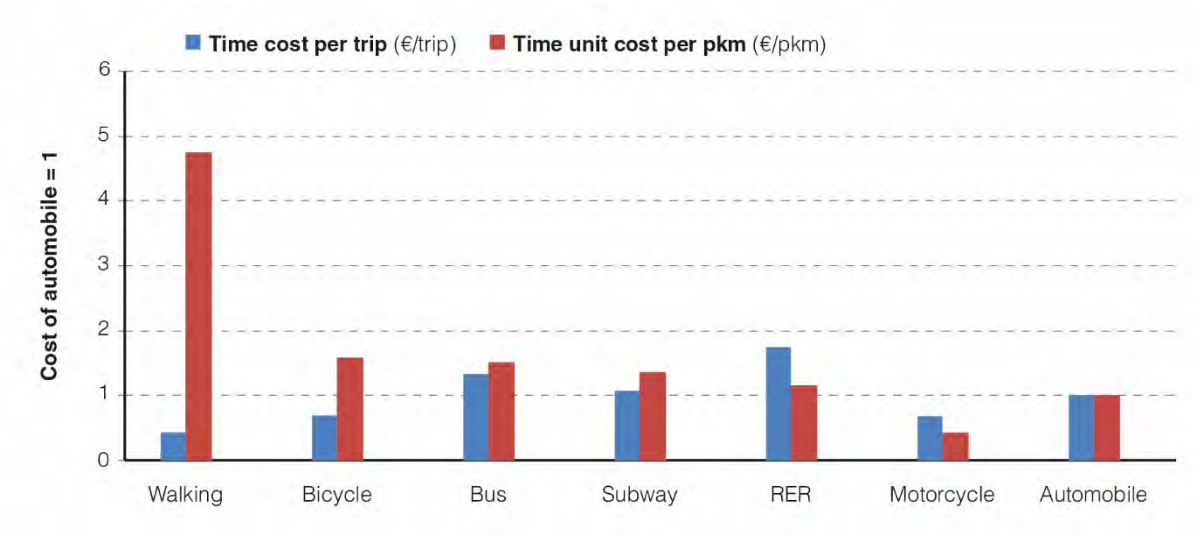

Figure 4.2.20. Time cost per trip and pkm by mode in Ile-de-France

Source: Created by the author

From next figure we can see that the cost of travel time for motorized vehicle use is more economical than public transport, and that non-motorized modes are much less competitive in terms of time cost. Indeed, Yokohama still has very few bicycle lanes at the moment, and the climate environment in Yokohama is another important factor for the use of non-motorized modes, because one has to consider energy expenditure in the sub-tropical climate.

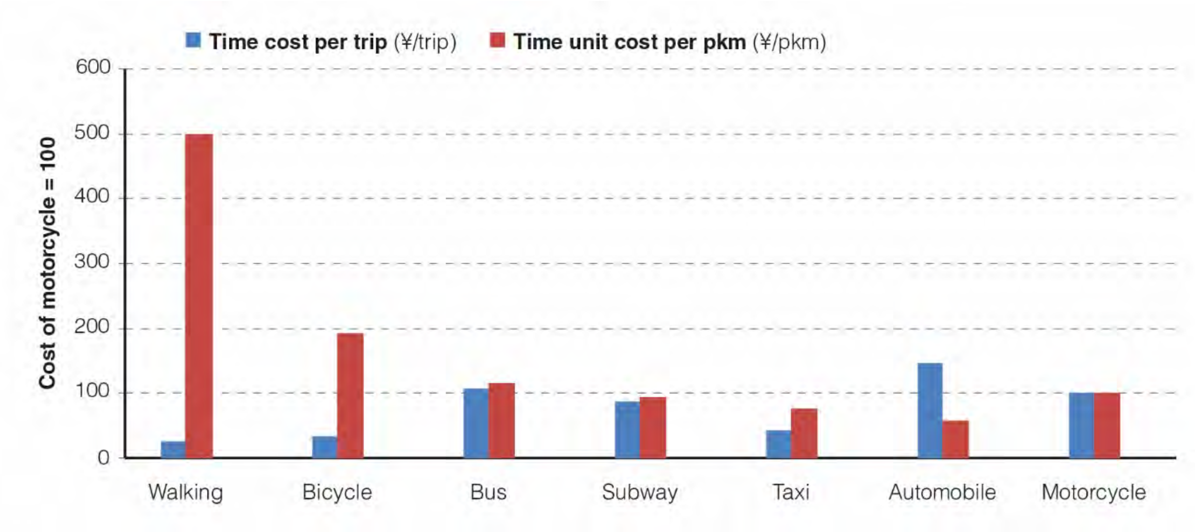

Figure 4.2.21. Time cost per trip and pkm by mode in Yokohama

Source: Created by the author

Cycling in Yokohama is still a widely used mode (8%), although its cost of time due to low speed is higher than motorized vehicles and buses. This phenomenon on bicycle use in Yokohama can be explained in two reasons: one is the costly monetary cost constraints related to the use of motorized vehicles (car and motorcycle) due to some income gap for the inhabitants, the other is the rather low capacity of the public transport network. On the other hand, these monetary cost constraints associated with the use of motorized vehicles for cyclists may provide a potential opportunity for public transport in Yokohama.

In addition, we also compare the modal share per pkm and the cost of time together in these cities to demonstrate that the time cost factor can reflect the modal choice of travellers now as a function of travel distance. Thus, we can see from the next three figures that the motorized vehicle mode is more frequent for daily trips at present, because the travel distance of motorized vehicles is longer than others. On the other hand, the modal share of non-motorized modes, including cycling and walking, relative to the pkm are still lower than the other modes. In addition, the cost of time for the walking mode is higher than the others. That is to say, we can say that the motorized mode is more popular because of the cost of time for economical travel.

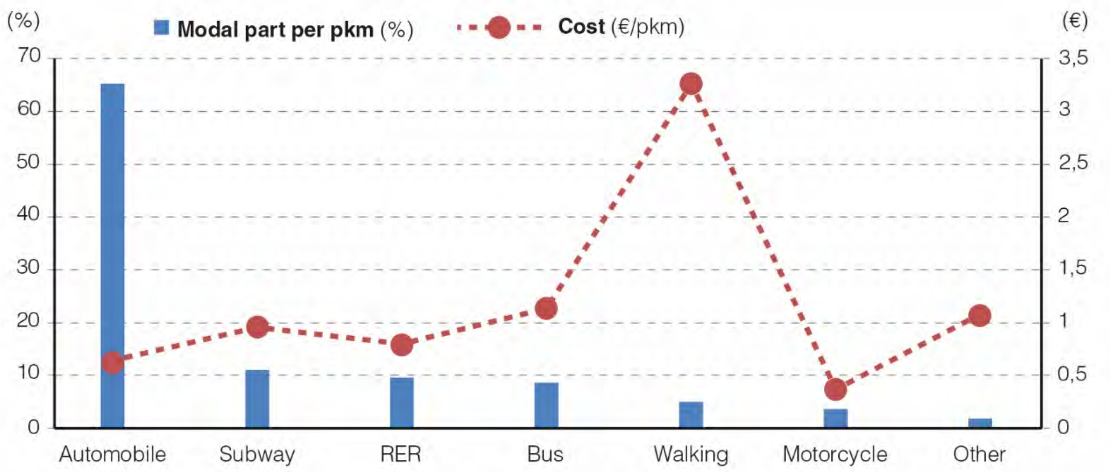

Figure 4.2.22. Modal share and cost of time of modes in Ile-de-France

Source: Created by the author

As for Yokohama, motorized vehicles account for most of the pkm traffic in the city compared to public transport, and the cost of time for motorized vehicle use is also cheaper than for public transport use. In other words, the modal choice of individuals has a weak relationship with the time cost of the modes.

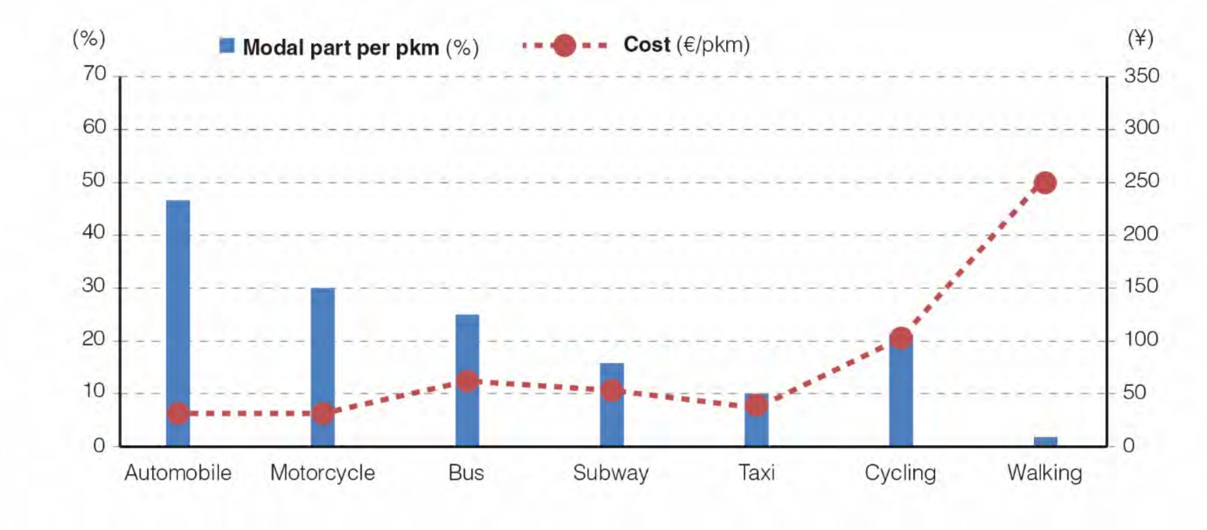

Figure 4.2.23. Modal share and time value of modes in Yokohama

Source: Created by the author

4.2.8. Findings

After presenting the comparison between the cost of time and modal share as a function of travel parameters related to speed, distance and the value of time by mode, we found that the time factor can effectively influence the modal choice of users. This result may also reflect a relationship between user income, modal choice and vehicle speed.

To evaluate the cost of time in the synthesis of the total cost of travel related to the analysis of the competitiveness of the modes in our research, we consider only the value of the average time for all modes. For this, we will use the value of time 10€/hour for Ile-de-France according to the result of the empirical analysis.

4.3. The monetary cost to users

According to the definition of total travel cost in Section 7, the vehicle expense is an internal and monetary cost. In addition, we can also distinguish these detailed user costs according to fixed and variable costs. The first component is the fixed user cost, and therefore includes the cost of owning the vehicle (estimated by the annual depreciation cost of the vehicle etc.), the cost of insurance and the cost of the annual vehicle tax etc. The second component is the fixed user cost, and therefore includes the cost of owning the vehicle (estimated by the annual depreciation cost of the vehicle etc.). The second component is the variable user cost, which is influenced by the frequency of use. It mainly includes the cost of operating the vehicle, including the cost of maintaining the equipment, the cost of fuel, the cost of parking and the cost of public transport passes.

The user cost for motorists accounts for about 41% of the total cost of travel according to Litman's (1996) research in the United States, where the carrying cost is half the user cost of travel. In other words, the carrying cost relative to the fixed cost is the second highest cost after the cost of time relative to other costs in a trip. However, to use the walking mode, passengers do not need to pay the carrying cost. In addition, the carrying cost of PT modes is the responsibility of communities, but it is zero on the passenger side. We will first present the classification of user cost in the following paragraphs according to modes of transport, the decomposed component.

4.3.1. Carrying costs

To present the user cost, we proceed in two parts: one is the carrying cost, and the other is the variable user cost. The carrying cost, which means the invariable cost per year, is mainly made up of the acquisition cost of the vehicle and the insurance expense, etc., which is the cost of the vehicle. In fact, the acquisition cost does not mean the cost of purchasing the vehicle, but focuses on the cost of wear and tear and depreciation. In general, the cost of wear and amortization can be calculated by the initial acquisition cost and the life of the vehicle. All modes have a wear and tear and depreciation cost, except for the acquisition cost of the step which is assumed to be zero in our research. Therefore, we will show the evaluation process for the acquisition cost below by mode.

4.3.1.1. Non-motorized mode

Considering their cost in terms of time, the monetary expenses of non-motorized modes are modest. In general, these expenses can be neglected for non-motorized modes because this cost is too small compared to the others, especially for the market. However, they are very real in reality and should not be regarded as zero. We shall therefore try here to take account, in the broadest sense, first of all of user expenditure for non-motorized modes.

Non-motorized modes include only two modes: foot mode and bicycle mode. We do not explore the acquisition cost for the foot mode, because the cost is almost zero, if we do not consider the depreciation of the shoes. Moreover, this user cost for the walking mode is too low in relation to the cost of time. Therefore, we present here only the fixed user cost of the bicycle for the non-motorized mode.

<u>In Ile-de-France</u>

The acquisition cost varies from less than €150 to more than €1500 in France (Papon, 2002). The article of the official journal of the French republic of the decree of May 28, 1990 for the civil personnel of the administration fixes at €165 in 1999 the allowance of first stake of bicycle. The average price of imported bicycles, representing 41% of the French market was €163,68 in 2000. The average life of the bicycle can be estimated at 7,44 years. Therefore, the depreciation cost can represent €22/year. For a regular cyclist travelling 2000km per year, the depreciation cost reaches €0,012/pkm. Therefore, we will use this value to estimate the private cost.

4.3.1.2. Motorized mode

The motorized mode consists mainly of the three modes: motorcycle, PV and cab. The acquisition cost is an internal fixed cost, which results in depreciation, to which insurance is added. In addition, we also have to take into account other internal costs, such as fuel and fuel tax, etc.

A. Motorcycle

First of all, the cost of the motorcycle must be differentiated by the size of the cubic capacity, because the cost of fuel, the amount of insurance and the cost of spare parts for maintenance are quite different according to the size of the cubic capacity. Therefore, we have to consider both the moped and the motorcycle.

In Ile-de-France

Spending on motorized two-wheelers must be divided into two categories: one is mopeds, with a cylinder capacity less than or equal to 50 cc, which are not subject to registration; the other is motorcycles, with a cylinder capacity greater than 50 cc, which are subject to registration. According to *STIF*'s report, the capital expenditure corresponding to vehicle purchases for two-wheel mode is estimated on the basis of an average list price for motorcycles and mopeds. Therefore, in the following table, the capital expenditure was calculated using average cost. In addition, the acquisition cost is evaluated in the form of an annuity of depreciation. Because of the data available in Ile-de-France, the unit cost for mopeds and motorcycles is not calculated. On the other hand, we can assume that the average purchase price for motorized two-wheeled vehicles (new) is around €2,*500* (*including tax)* based on observed data related to the vehicle cubic capacity at the site, which we consider to be between 50 cm3 and 150 cm3. Moreover, we can see that the cost of insurance for motorcycle use is relatively higher, due to the fact that this cost is linked to the specific insecurity of the mode.

Type	**Value** (2003)
Total park in Ile-de-France (1)	393 000
Average mileage per vehicle (km/year) (2)	4139
Amortization annuity (€ 2003/year/veh) (3)	343,1
Insurance (€ 2003/year/veh) (4)	458
Unit cost (€ 2003/pkm)	0,193
Fixed cost of detention (€ 2003/pkm) (5)	0,193

Figure 4.3.1. Cost of ownership of two-wheeled vehicles in Ile-de-France
(average moped/motorcycle)
Source: Gallez, 2000; STIF, 2001; STIF, 2005

Note: 1. The total two-wheeler fleet includes mopeds and motorcycles, with a moped fleet of 130,000 and a motorcycle fleet of 260,000 in 2003 (STIF, 2005).
2. The average mileage per vehicle is estimated for mopeds and motorcycles with an annual mileage per moped of 2600km/year and 4900km/year for motorcycles (STIF, 2005). Motorcycle life is 9 years for the new motorcycle.
3. Insurance costs represent a total expense of €180m, STIF 2005
4. The motorcycle occupancy rate is 1 person per vehicle (STIF, 2005)
5. The average distance as the crow flies on a two-wheeler in Ile-de-France is 9,1km.

B. Automobile

According to the definition of fixed cost, the cost of owning an automobile mainly includes the acquisition cost, insurance cost and taxes. Therefore, we will also show here the cost of owning an automobile in three main parts: the annual depreciation cost, the annual insurance cost and the annual fuel tax cost.

Ile-de-France

Ownership cost is measured in the form of an annual depreciation allowance, the value of which is updated according to changes in the price of new vehicles. The cost related to the purchase of used PV is not taken into account in the calculation here. Therefore, it is assumed that all vehicles in the fleet are purchased new and have a life of 12 years (Gallez, 2000). Formula (23) shows the relationship between the depreciation year and the price of new vehicles. Thus, the depreciation annuity A is estimated on the basis of an initial cost PT corresponding to the price of new vehicles[12] in t given by the CCFA, and with a discount rate of 8%[13], a value set by the General planning commission for public investments. Therefore, the formula can be represented below.

$$C_t = \sum_{1}^{n} \frac{A}{(1+0.08)^n}$$

(23)

In addition, insurance expenses, taxes, vignettes, etc. are estimated from the value of the transport account, in relation to vehicle-kilometres.

In Ile-de-France, passenger PV registration expenses are calculated based on the overall amount collected by the region. In addition, the number of vignettes collected by the departments is provided by the General Tax Department. Insurance expenditure is calculated according to the product of PV fleet by the unit premium for the region. And expenses for obtaining a driving license are calculated on the basis of the average cost of a license multiplied by the number of licenses issued in the year.

[12] The average purchase price of a new car was €20,200 (including tax) in 2003 (STIF, 2003).

[13] The notion of discounting is based on the idea that the value of a euro today is not the same as the value of a euro in a few years' time.

Type	Value (2003)
PV parking in Ile-de-France (million€) (1)	4,943
Travellers x kilometres (millions pkm) (2003)	55 000
Total kilometres in Ile-de-France (millions vkm) (2)	43 000
Acquisition cost	
Initial purchase cost (€/veh) (3)	20 200
Service life (year)	12
Amortization annuity (€/veh)	3291
Other fixed costs of use (4)	
Cost of fixed charges (million€)	5682
Cost of fixed charges per vehicle (€/veh)	1149,5
Parking cost (5)	
Annual cost of home parking (€/veh/year)	960
Unit cost of ownership per vkm (€/pkm) (6)	0,435
Unit cost of ownership per vehicle per km (€/pkm) (7)	0,340

Figure 4.3.2 Private vehicle ownership costs in Ile-de-France

Source: Estimation by the author from EGT, 2011; STIF, 2015

Note: 1. The passenger PV fleet in the Ile-de-France was 16.8% of the national fleet in France in 2003.
2. Here, for all expenditure excluding fuel and parking, an imputation coefficient is used which takes into account the fact that only part of the annual mileage is carried out in Ile-de-France ; this coefficient, which is equal to approximately 0.7, is obtained from the ratio between the average mileage in Ile-de-France and the average mileage for the whole of France. The cost of ownership per km is calculated on the total km (Ile-de-France and outside Ile-de-France) of the vehicle.
3. We take again here the STIF documents, it is a high value.
4. This includes insurance and tax (car registration) and financial charges. (STIF, 2005)
5. The average travel distance by PV in Ile-de-France is 6.4km, see DREIF 2001.
6. The monthly price of parking is estimated at 120€/month/car in Paris, 80€/month/car in PC and 60€/month/car in GC. For this, we estimate the average annual parking price for a PV in Ile-de-France using the average price of 80€/month/car in our study. It should be noted that a part of the vehicles, those parked on roads, do not incur this cost. A vehicle that thinks while benefiting from the on-street parking favourites only weighs around 100€ per year.
7. This is the total annual mileage in Ile-de-France, in addition, the average number of passengers per PV is 1.28 (excluding taxis) according to STIF 2002-2003.

C. Taxi

First of all, we only calculate the cost of taxi ownership for consistency with the car, bearing in mind that the user only perceives the variable costs linked to the fare. To do this we will present taxi costs under the user cost part.

4.3.1.3. Public transit

As for the private cost of public transport, it consists mainly only of the expense of tickets or season tickets, because the cost of infrastructure and rolling stock etc. is entirely a public cost. That is, within the framework of the private cost of passengers, there is no fixed cost of public transport charged to users.

On the other hand, the cost of transit fares, which is a variable cost, depends on the distance travelled and the number of daily uses. Thus, the carrying cost of public transport is considered to be zero for users according to the typological definition of cost.

4.3.2. Variable cost of use

The variable user cost mainly includes the cost of operating vehicles (maintenance, fuel, etc.) and the cost of parking (particularly for individual PV away from home), tickets or season tickets for public transport and any tolls. We will first present the process for estimating the variable user cost of modes.

4.3.2.1. Non-motorized modes

For the user cost of the walking mode, it is relatively assumed to be zero. On the other hand, we have to consider the variable cost of the walking mode related to the expenditure of regular instruments (depreciation of shoes, etc.). However, the assessment of the variable cost of walking is highly variable, since it includes many variable parameters, such as the character of the travellers, the road situation, etc., and the cost of the regular instruments (e.g., footwear depreciation, etc.). Therefore, we only aim to calculate the variable user costs for cycling.

In Ile-de-France
According to Papon's report (2002), we can report the variable cost of the bicycle, he also indicated that the cost of maintenance is 0.024 €/km, plus 0.028 €/km for accessories and clothing, so the variable cost of bicycle use is in total 0**.052 €/pkm,** this value is retained for the synthesis in our research.

4.3.2.2. Motorized mode

Variable [14] user cost for motorized modes generally includes the cost of fuel and vehicle maintenance, which are always estimated from an average value from the passenger transportation account for the trip, related to vehicle-kilometres and pkm.

A. Motorcycle

In Ile-de-France

[14] Variable cost mainly means that the user cost should depend on the mileage of the trips, as well as fuel, maintenance and accessory expenses.

The variable cost for motorcycles is mainly made up of two parts: one is fuel expenses and the other is made up of maintenance and accessories expenses.

Type	**Value** (2003)
Total park in Ile-de-France (thousands)	393
Average mileage (km/year)	4139
Fuel expense (million€) (1)	82
Maintenance and accessories expenses (million€)	81
Variable cost per vehicle (year/veh)	414,76
Occupancy rate (traveller/veh)	1.0
Variable cost of use (pkm)	0.100

Figure 4.3.3. Variable cost of using a motorcycle in Ile-de-France

Source: STIF, 2015

Note: Fuel expenses are calculated on the basis of average annual mileage, unit consumption per type of vehicle on urban routes and the corresponding fleet, e.g. 3.3 litres/100km for mopeds and 4.4 litres/100km for motorcycles.

B. Automotive

Ile-de-France

In figure 4.3.4, we also need to separate the variable user cost into two parts to reflect the unit cost of parking and the unit cost without parking. In fact, the cost of parking for the automobile in Ile-de-France is only 16% of the variable user cost for the automobile. On the other hand, the fuel expense is significant compared to the costs of maintenance and parking.

Type	**Value** (2003)
PV parkings in Ile-de-France (million€)	4.943
Passengers x kilometres in Ile-de-France (millions pkm)	55 000
Total kilometres (millions pkm)	43 000
Cost of fuel (million€)	3 107
Operating expenses (million€) (3)	1 121
Parking (million€) (1)	1 040
Maintenance (million€)	2 100
Occupancy rate	1,28
Unit cost of parking (pkm) (2)	0,018
Unit cost of maintenance and fuel (pkm)	0,115
Variable cost of use per pkm	**0,133**

Figure 4.3.4. Variable cost of automobile use in Ile-de-France

Source: Estimates based on STIF data, 2011 and 2015

Note: 1. Including also the expense of tolls and fines. In addition, the cost of on-street parking is estimated based on hourly costs depending on the zone, and the predefined duration for the type of trip. A distinction is made between off-street parking (free, made available by the employer for commuting to work) and paid off-street parking (paid, for commuting to and from work, at an hourly rate of 10 F/h in Paris, 5 F/h in the inner suburbs and free in the outer suburbs in 1998). (STIF, 2001)
2. This is the cost of out-of-home parking, because the cost of in-home parking is included in the fixed cost.

3. User expenses include lubrication, fines and tolls in Ile-de-France

C. Taxi

Ile-de-France

Operating expenses are evaluated based on data provided by the National federation of taxi Craftsmen (*Fédération Nationale des Artisans du Taxi*, FNAT), including the cost of maintenance, driver's salary, fuel and loan repayments, as shown in the following table. However, this variable user cost is rather the cost perceptible to the driver (owner or lessee of the vehicle). The perceived variable user cost is the actual cost paid by travellers.

To do this, we need to take into account the perceptible variable cost of taxis under the aspect of the traveller, because the private cost, which includes the cost of time and use, belongs to the cost felt by travellers in the typological classification of our research. Therefore, we aim to present the rule for taxi fares in Ile-de-France as follows: firstly, for Parisian taxis, and secondly, for all taxis outside Paris, we use two principles for pricing in Ile-de-France.

Prefecture	**Pick-up charge** (€)	**Trip price** (€/km)			
		A	B	C	D
Paris (75)	2,20	0,86	1,12	1,35	-
Hauts-de-Seine (92)	2,00	0,67	1,01	1,34	2,01
Seine-Saint-Denis (93)	2,00	0,64	0,89	1,28	1,79
Val-de-Marne (94)	1,60	0,73	1,10	1,46	2,19
Seine-et-Marne (77)	2,20	0,70	0,94	1,40	1,88
Yvelines (78)	1,80	0,67	1,00	1,34	2,00
Essonne (91)	2,10	0,68	1,02	1,36	2,04
Val-d'Oise (95)	2,40	0,62	0,93	1,24	1,86

Figure 4.3.5. Taxi fares in Ile-de-France

Source: FNAT, 2017

Based on the applicable fare classification for taxis in Ile-de-France, we can estimate the variable user cost for the average distance travelled by taxi in different zones in Ile-de-France. We use STIF data to take into account the cost of taxi use per pkm. For this, the variable cost of taxi use is €1.42 per pkm (the perceptible user cost of a passenger).

4.3.2.3. Public transit

The variable user cost for the PT mode corresponds to the expenses related to the purchase of tickets or passes by users. In addition, the PT mode can be divided into two: bus and rail.

A. Bus

Ile-de-France

To estimate the variable cost of using PT in Ile-de-France, we need to know the structure of PT revenues. Total PT revenue mainly includes the three fares: zonal fares (including carte orange, and imagine R etc.), tickets and other fares.

However, it is very difficult to separate the revenue from zonal fares according to the modes of PT (RER, Subway and Bus) in Ile-de-France. For this reason, RATP's cost accounting gives us a breakdown of total traffic revenues by network (Gueguen-Agenais, 2008):

Mode	Subway	RER	Bus
Share of revenues (%)	43,02	22,4	34,58

Figure 4.3.6. Breakdown of revenue by RATP network

Source: RATP, 2013

Therefore, we then apply this breakdown to 2013 fare revenues for RATP (€1561.50 million including tax) and estimate unit revenues per pkm for bus use to be €0**.22** per pkm based on fare revenues (€539.96 million) and total traffic (€2469.30 million pkm) for the bus.

B. Rail

Ile-de-France

Rail includes subway and RER networks. We can estimate the variable cost per pkm in subway and RER according to the three ticket revenues (zonal, tickets and other titles). To estimate the user cost of rail in Ile-de-France, we can also apply the allocation to 2013 fare revenues, see the following table. Therefore, the variable user cost of rail (subway and *RER*) is estimated by fare revenues and traffic by mode, see the following table.

Revenue	Subway	RER
Tariff revenue (million€)	671,72	349,82
Trafic (million/pkm)	6014,9	4084,1
Variable use cost (€/pkm)	0,11	0,09

Figure 4.3.7. Variable user cost of rail in Ile-de-France

Source: RATP, 2013

Note: A user cost identical to that of the RER-RATP and for the cost of the RER-SNCF is assumed.

4.3.3. Total cost of using the modes

Based on the calculated results of the fixed and variable user costs for the above modes, we can organize the fixed and variable costs for total user cost together in Tables IX-19 to 21. The unit user cost of travel per pkm for motorized modes is higher than for non-motorized modes and the public transport mode (especially the user cost for PV is three to five times higher than for rail). The cost of PT is quite attractive in terms of passenger costs.

Furthermore, we see here that the unit user cost per pkm for taxis is probably higher than for other modes, which may reflect the fact that taxi use in Ile-de-France is a luxury travel expenditure compared with other modes according to the user cost evaluation. And the fixed user cost for passengers is nil, this cost belongs to the cost borne by the driver.

Moreover, these estimated unit costs can be compared with the distribution of mode use according to wage level to observe the essential relationship between the user cost of travel and mode use behaviour.

Ile-de-France

Mode	**Fixed cost** (€/pkm)	**Variable cost** (€/pkm)	**Cost of use** (€/pkm)
Walk	-	-	-
Bicycle	0,012	0,052	**0,064**
Motorcycle	0,193	0,100	**0,293**
Car	0,340	0,133	**0,473**
Cab	-	1,420	**1,420**
Bus	-	0,220	**0,220**
Subway	-	0,114	**0,114**
Rail	-	0,090	**0,090**

Figure 4.3.8. User cost per pkm according to the modes in Ile-de-France

Source: RATP, 2013; STIF, 2015

4.3.4. Summary of the private cost to be borne by users

We present here the total private cost, which is made up of the cost of time and the user cost in order to estimate the modal choice behaviour of individuals, because the private cost, which is one of the most perceptible travel costs for users, can directly show the level of attraction of the different modes for passengers. We can observe that the cost of time plays an important role for the vehicle in the three metropolises. Time, which is always higher for public transport than for individual modes, can nevertheless be compounded in some cases for a lower user cost. This is clearly the case in Yokohama. Finally, the difference in the cost of time for PV and motorcycles is different. In Ile-de-France, the cost of time for motorcycles seems to be much lower than for cars, thanks to the high average speed of motorcycles compared to that of cars. On the contrary, the cost of motorcycle and PV time is very close in Yokohama, due to the fact that the average motorcycle speed is as close as the average PV speed in the Japanese city. The reasons are twofold: the speed limit for motorcycles in these two cities is lower than for cars, and at the same time the motorcycle does not drive in the expressway, it only drives in the urban trunk roads.

This absolute advantage of the motorcycle in Ile-de-France was not for a significant use, due to the perceived insecurity of this mode. Consistent with descriptions of private cost, reducing travel time is probably an effective direction of transportation policy to encourage the use of PT and cycling. Examples of actions that could improve the attractiveness of public transport are the establishment of interchange hubs, the improvement of the quality of connections, the integration of the transport information system, and the combination of the public transport ticketing system.

Finally, the unit user cost of motorized modes is always the highest except for walking and taxi mode, because the variable cost of taxi use is very expensive and the cost of walking time is very high (low speed).

Cost (€/pkm)	Walking	Bicycle	Motorcycle	Automobile	Bus	Subway	RER
Time cost	3,57	1,25	0,44	0,55	1,00	0,83	0,62
Usage cost	-	0,06	0,29	0,53	0,22	0,11	0,09
Total	3,57	1,31	0,73	1,08	1,22	0,94	0,71

Figure 4.3.9. Private cost per pkm to be paid by users according to the modes of transport in Ile-de-France

Source: RATP, 2013; STIF, 2015

Note: The cost of time for PT (including bus, subway and RER) is 0.7 €/pkm

Comparison of modal split and private cost

Next figure presents the relationship between modal split and private cost per pkm in Ile-de-France to explain the relationship between modal choice and the private cost of modes. In fact, we can first observe that the private cost per pkm by PV is certainly higher than that of public transport and motorcycle, because the cost of using a PV is always higher than other modes from a passenger point of view. However, the modal share of PV per pkm is still high (about 67% in Ile-de-France) compared to public transport and non-motorized modes. To explain this contradiction between modal split and private cost, we can observe that PV is mostly frequently used in areas that do not have a strong public transport network. For example, in Ile-de-France, 80% of PV traffic is on links between suburban municipalities.

On the other hand, the motorcycle is well presented the coherent link between modal split and private cost in Yokohama. This is why we can see that most Asian cities have the same problem of 2 or 3 motorized wheels in the urban transport system, see section 2. On the contrary, this mode is still little used for daily trips in Ile-de-France, although it has the most economical private cost for travellers.

Moreover, the level of public transport attraction related to private cost in favour of individual choice over the motorized vehicle is always different. In Ile-de-France, rail transport (subway and RER) is relatively more competitive than motorized vehicles and buses, and this mode has a 20% modal share per pkm. As for the use of bicycles in these areas, the market remains low in the Ile-de-France (less than 3%), because the private cost is high (due to the high cost of time).

Mode	**Modal share** (1)	**Private cost** (€/pkm)
Automobile	67,55%	1.08
Subway	10,45%	0.94
RER	9,37%	0.71
Bus	4,83%	1.22
Walking	4,92%	3.57
Motorcycle	2,54%	0.73

Figure 4.3.10. Comparison of modal split and private cost in Ile-de-France

Source: RATP, 2013; STIF, 2015

Note: 1. Modal share (%) according to pkm.

Following a description of the relationship between modal share and private cost, we can see that private cost related to dollar value can provide a reasonable benchmark of modal choice for travellers. However, there are still other decision factors that may influence the modal choice of travellers, such as the level of transport comfort, the accessibility of public transport and infrastructure for non-motorized mode, and so on.

On the whole, private cost (generalized cost) is still presented in classical travel demand modelling theory to simulate modal choice of traveller, however, public and external costs must also be taken into account in the context of sustainable development, because users of motorized vehicles do not always sufficiently pay for their social responsibilities, especially the costs related to externalities. For this reason, if we consider the overall cost of travel by mode, the result evaluated may give us another avenue for future urban transport development.

4.3.5. Costs borne by employers for their employees in Ile-de-France

Following the evaluation of the private cost by mode, we need to specify, in Ile-de-France, certain private costs to be charged by employers for their employees. Indeed, employers contribute to the partial coverage of travel expenses to work in three ways:
- when providing parking space for their employees;
- by paying the transport payment;
- reimbursing 50% of the cost of employee PT passes.

First, for the provision of employer-paid parking for employees, the following table provides elements to estimate this expense.

Articles		Paris	Île-de-France
1.	Number of workers (million)	1.6	3.4
2.	Workers who have an off-street parking space at their disposal (%)	33%	71%
3.	Workers with access to parking who come to work by car (%)	24%	66%
4.	Value of one place per year (€/year)	1440	840
5.	Value of potential places (million€)	553	1885
6.	Value of occupied places (million€)	182	1338

Figure 4.3.11. Estimated employer parking expenses in Ile-de-France

Source: Estimation by the author from RATP, 2013; STIF, 2015

Note: (5) = (1*3*4) and (6) = (1*2*3*4)

According to the table above, it can be estimated that the employers' contribution to employee parking is between €1,5b (€0,182b+€1,338b) and €2,4b (€0,553b+€1,885b) in Ile-de-France. For this, an average of €1,9b can be estimated for employer-related spending on employee parking. Moreover, compared to the 43 billion vkm in Ile-de-France in 2003, this represents a contribution of €0,044/vkm or €0,034/vkm for the unitary parking expenditure borne by employers. This cost is a private cost, even if employees do not pay it. For this reason, it is included in the private cost for PV use in our model.

Secondly, for employee PT use, employers contribute €2,9b, of which €2,3b are related to transportation payments and €0,6b to the reimbursement of half of employee season tickets. Therefore, compared to the 24,3b pkm of public transport, this represents a contribution of €0.12/pkm for the use of public transport in Ile-de-France.

Should this contribution be considered a public or a private cost? All positions on this subject are defensible. As a matter of principle, these expenses are compulsory expenses and could therefore be included in public costs. These expenses contribute to moderating automobile traffic, and it can be argued that they benefit motorists as well. For this reason, we will take an intermediate view here.

The €0,6b related to subscription reimbursements are considered as private support, to be added to private revenues. This expenditure is in fact directly related to the use of public transport for assets. In other words, this expenditure can also be counted as a private cost.

The €2,3b in transportation payments will make it possible to offer a PT system with a range of services and fares to system users on the one hand, and to moderate congestion for PV use on the other. In an accounting approach, we will allocate the amount corresponding to public transport, reserving in an economic approach to allocate part of this amount to motorists.

4.4. Public cost

Here we group together the investment and operating costs of roads and public transport. We approach them from an accounting perspective (related to recorded cash flows) and then from an economic approach (related to capital depreciation).

In our research, we first assume in our evaluation that the walking mode does not include any public costs, although there is still the cost of sidewalks. In addition, the bicycle mode has only the public cost of space consumption in the public cost that will be neglected.

Moreover, we also need to assess the revenues (referred to as the public return), including also tax and ticket revenues, that reduce public costs to avoid double counting in private and public costs. The gross cost relative to total operating and capital expenditures, less transport revenues (including specific taxes), is the net public cost that is normally borne by government, see figure 4.4.1.

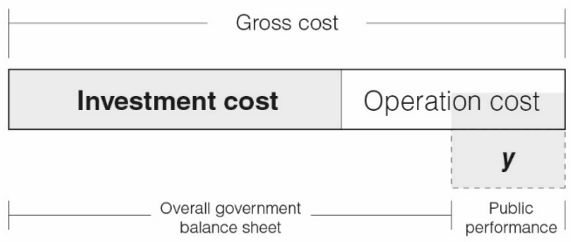

Figure 4.4.1. The public cost structure

Source: Created by the author

4.4.1. Public costs related to the use of roads

The public cost of motor vehicle use can be divided primarily into two expenditures: the first is the operating expenditure, and the second is the capital and land expenditure. Thus, we can reconstruct the public costs of PV into three parts: operating costs; capital costs; and revenues that are deducted from operating costs.

Operating costs: the cost of maintaining the existing road network is estimated on a global basis for the entire road network, by relating the annual expenditure to the number of vehicle-kilometres travelled.

Capital costs: the capital and land costs associated with the creation of new roadways for the highway cover two types of road use:
- a circulating use, corresponding to land acquisitions and road infrastructure construction costs;
- parking use, corresponding to the cost of space consumption[15] for on-street parking.

Public performance: revenues related to motorized vehicle travel, the revenues to be taken into account are: parking and specific taxation (excluding VAT) on vehicle ownership and use.
Qin (1996) provided the architecture of public road cost by financial category, see figure 4.4.2.

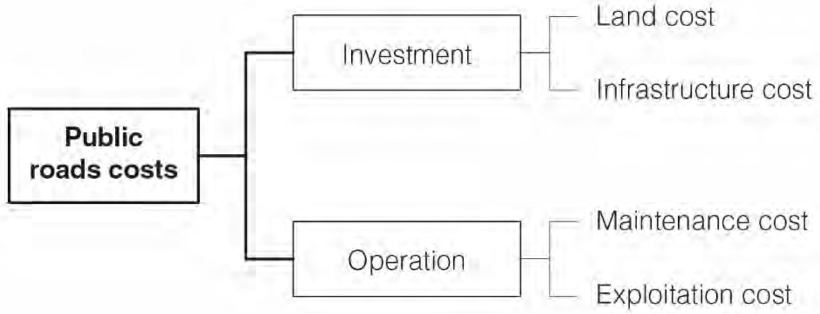

Figure 4.4.2. Public roads costs distribution

Source: Qin,1996

Following the general definition of public cost related to operating and capital expenditures above, we can present the methods for evaluating public costs. First of all, the evaluation of the costs of operating road networks is relatively simple when it is tracked in community budgets, which is the case in Ile-de-France. The evaluation of investment costs is much less simple. It can be based on an economic approach or an accounting approach, and the results obtained differ significantly. The accounting approach is relatively simple: it consists of evaluating the annual flows of investment in the road network and relating them to the activity they support. It focuses on the expenditures of the year and ignores the amortization of past expenditures as well as possible future expenditure requirements. It takes note of the destination of the road network for traffic use, and does not attempt to evaluate land costs. Applied to Ile-de-France, it had an investment cost of 0.0138 €/vkm in 2003. It is well adapted to the analysis of a stabilized system, not having to face important traffic growths.

The economic approach: it estimates the value of the existing capital stock, deducts an annual depreciation cost from it, and adds to this land cost related to the consumption of space. It is suitable for a non-stabilized system where the public authorities have to develop the networks and where each marginal km incurs significant development costs.

[15] Space is a rare and highly coveted asset in dense urban areas. Its sharing between the various urban functions (inhabitants, productive activities, roads, green and recreational spaces, etc.) is a major political choice with a direct impact on the living conditions of city dwellers. Roads and parking lots take up a large part of urban space and city dwellers are less and less able to tolerate anarchic parking and the cuts in the urban fabric caused by expressways. The efficiency of urban transport in terms of space consumed differs greatly from one mode to another.

The results of the accounting approach and the economic approach are somewhat similar when the costs of space consumption are added to the annual operation. Finally, it will be seen that the estimates differ greatly, since the accounting approach gives an estimate 2 to 12 times lower than the economic approach for the case of Ile-de-France (see the following section).

The accounting approach reflects an average cost related to the existing network. It is well suited to the case of both Ile-de-France and Yokohama, because traffic is no longer growing in this region, and public decision-makers no longer wish to develop the road network.

The economic approach, in which the cost of land is taken into account, seems to be better suited where the networks are more recent and not yet amortized, and where the public authorities continue to develop roads to cope with the prospects for traffic growth.

Following the description of the approaches to the evaluation of the public cost of road use, we can respectively estimate this public cost, which includes the operating and investment costs, for the Ile-de-France using the accounting approach in the following sections.

Ile-de-France

According to the classification of public cost above, we can represent as a whole in two parts: the operating cost and the capital cost.

The cost of operation
In 2003, public authorities spent €1,5b on roads for passenger travel[16], including €862m for operating expenses. Thus, the public cost of annual operating expenditure per vkm and pkm is €0,02/vkm and €0,016/vkm in Ile-de-France in 2003.

The cost of investment
To evaluate the public cost of capital expenditures, we can show the results of the evaluation of this cost in two approaches: the accounting approach and the economic approach, see the following table.

[16] The roadway is used by different types of users, including heavy goods vehicles. According to the STIF report, 1.5 billion represents expenditure on passenger car travel alone (Source: STIF).

	Ile-de-France		
Accounting approach *(A1)*		596	
Capital expenditure (million€)			
Passenger private vehicle traffic (million pkm)		43 000	
Investment cost per vkm (€/pkm)		0,0138	
Economic approach *(A2)*			
Existing network *(a1)*			
Capital expenditure (million€)		596	
Passenger private vehicle traffic (million pkm)		43000	
Investment cost per pkm (€/pkm)		0,0138	
Cost of space consumption *(a2)*	Paris	PC	GC
Price of land (€/m²) (1)	1650	820	330
Amortization annuity (€/m²) (2)	115,63	57,47	23,12
Number of hours of occupancy per year (h)	3600	3600	3600
Land hourly cost (€/h.m²)	0,0321	0,016	0,0064
Traffic space consumption (m².h/pkm)	2,81	3	4,67
Unit land cost in circulation (€/pkm)	0,09	0,048	0,03
Parking space consumption (m².h/veh) (5)	9	9	9
Unit land cost in parking (€/veh)	0,289	0,144	0,058
New track/exceeded traffic *(a3)* (3)			
Investment cost of a kilometre (million€)	141	66	28
Amortization annuity (million€)	9,88	4,63	1,96
Annual vkm (million pkm) (4)	60	32	24
Unit investment cost (€/pkm)	0,1647	0,1447	0,0817
Accounting approach			
Investment cost per vpkm (€/pkm)		0,011	
Economic approach			
Investment cost related to the existing road network *(a1+ a2)* (€/pkm) *(A1)* (6)	0,081	0,048	0,034
Investment cost of the new track *(a3)* (€/pkm) *(A2)*	0,129	0,114	0,064
Average investment cost (€/pkm) *(A3) = (A1+A2)/2*	0,105	0,081	0,049

Figure 4.4.3. Calculation of investment costs in Ile-de-France

Source: Gallez, 2001; STIF 2015

Note: 1. The valuation of the space (traffic or parking space) is based on a discount calculation, the general terms and conditions of which have been described above. The discount rate is 8%. In addition, a residual value is estimated at the end of the period for non-depreciable land (STIF, 2015).

2. For land that is not depreciable, a residual value is estimated at the end of the period. The study period is 50 years.

3. To estimate the investment cost of new roads, we consider the cost of building this type of road, which includes the land and the development of the roads if they were to be built today. The assumptions used for the cost of building one kilometre of expressway are differentiated by geographical area. The depreciation annuity is then related to vehicles * km per year on a one-km section (STIF, 2015). Thus, the annual capital expenditure on the expressway is estimated from the annual depreciation annuity of the cost of building one kilometre of new roadway, in relation to the annual traffic on a one-kilometre section of the same roadway.

4. Vehicles x annual km on a 1km section (STIF, 2015)

5. The cost of consumption of road space (cost calculated as for local roads), STIF (2015)

6. To estimate the cost of space consumption in the capital cost of the existing roadway, only the consumption of circulating space is considered.

According to the process of estimating the investment cost, we can see that the investment cost linked to the accounting approach (0.011€/pkm in 2003) gives an estimate 4 to 10 times lower than the investment cost linked to the economic approach in Ile-de-France, because the cost of space consumption linked to the land occupies the bulk of the investment cost according to the economic method. That is to say, in Ile-de-France, the investment cost must take into account 0.011 €/pkm according to the accounting approach, because the growth of road traffic is no longer increasing in Ile-de-France today. Moreover, new roads will be very rare in Ile-de-France, we only take into account the evaluation on existing network related to the economic approach.

Assessing space consumption, part 1

Space consumption in urban areas is an essential characteristic of the way transportation systems operate. In built-up areas, space is scarce and therefore expensive, but its consumption by the modes of transport does not always have a financial counterpart, apart from paid parking spaces on public roads: in this sense, it is an externality of the transport system.

An appropriate unit for measuring traffic space consumption has been developed by Marchand (1992). The m²/hour takes into account both the area used by a vehicle and the time during which that area is occupied. After describing and criticizing the calculation assumptions that form the basis for including space consumption in travel cost estimates.

To calculate the traffic space-time consumption (TSC), the following general formula for mode i:

$$CEC_{v,d} = (l*D_d)/Q(V_d)*n$$

Where l is the width of the lane used (meters); D_d is the distance of travel (meters) and $Q(V_d)$ is the value of the average lane throughput for speed V_d (veh./h) where $Q(V_d)$ is assumed by $(\rho*Vd)$ (ρ is the observed density on the lane). n is the vehicle occupancy rate (number of persons)

Following the general formula, we estimate the traffic space-time consumption per zone according to the respective correlative parameters:
- the average lane width in the urban area is assumed to be constant, set at 3.5m;
- the average speed per zone is 14km/h in Paris, 16km/h in PC and 20km/h in GC;
- PV occupancy rate is 1.28 in Ile-de-France.

4.4.2. The public cost of public transportation

The public cost for the public transport mode can also focus on capital and operating costs, among which capital costs can be assessed using the accounting and economic approach.

The cost of transit operations is simple to estimate using community accounts. As for the evaluation of the investment cost, the accounting approach is also relatively simple because it can be traced back to the annual public expenditures of communities. On the other hand, the evaluation of the investment cost linked to the economic approach must take into account the three main items: the cost of infrastructure, the cost of rolling stock and the cost of traffic space. Each of these costs has been estimated on the basis of a discounting calculation that takes into account the lifespan of the infrastructure, equipment or land.

The cost of the infrastructure, evaluated separately for different types of rail networks, such as subway or regional trains etc., is also included in the **cost of the infrastructure.** Several types of investment are distinguished according to their nature: civil engineering is the equipment; an initial cost and a life span can be associated with these different items.

The cost of rolling stock is estimated based on the annual depreciation of vehicles on each of the networks. The unit cost is obtained by multiplying the depreciation annuity of a vehicle by the overall volume of the fleet, and reporting this amount of traffic expressed in terms of pkm.

The cost of traffic space consumption is estimated for buses **operating** on the roadway. The method of calculation is identical to that used for PV.

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The public cost of public transport is broken down into two main parts: the operating cost and the capital cost, such as the presentation of the public cost of road use.

Operating costs

The operating cost is calculated by relating operating expenses excluding depreciation and amortization to the pkm of the network in question. Public transport operating expenses include personnel, energy, materials and other external expenses.

To evaluate this cost related to the different networks (Subway, RER and RATP Bus, RER SNCF and OPTILE Bus), we start from the operating costs per RATP network thanks to its cost accounting, and per SNCF and OPTILE network thanks to STIF data related to the travel account of passengers in Ile-de-France. In addition, STIF indicates that there was a total of €5,76b in 2003, of which 61% of operating expenses for RATP; 32% for SNCF and RFF and 7% for OPTILE. Therefore, we can estimate the operating cost per pkm per network in Ile-de-France, see the following table:

	Subway	RER	Bus	Total
Operating (million€)	1470	2543,8	1760,7	5756
Traffic (million pkm)	6014,9	14130,1	3877,3	24022
Operating cost (€/pkm)	0.244	0,18	0,454	0,24

Figure 4.4.4. Estimated operating costs of public transportation in Ile-de-France

Source: RATP, 2013; STIF, 2015

Investment costs

To evaluate the public cost related to capital expenditures, we must also take into account this cost related to the two valuation approaches: the accounting approach and the economic approach, in order to reflect the recurring cost and the cost of development.

The investment cost related to the accounting approach
As far as investment costs are concerned, STIF estimates that in 2003 the investment costs amounted to €1.1 billion, of which €160 million was for network extension, €434 million for rolling stock and €434 million for maintaining the potential and modernizing the networks. Thus, the average unit investment cost for public transport is €0.045 per pkm (total 2003 traffic of the RATP, SNCF and OPTILE is estimated at 24.3 billion pkm). However, it is difficult to separate this capital expenditure between the different networks. Moreover, we can see that this investment cost per pkm is lower than the operating cost of public transport because the growth of the public transport network in Ile-de-France is low.

The investment cost linked to the economic approach
According to the general description of the public cost evaluation linked to the economic approach, we can estimate this cost in three parts: infrastructure costs, rolling stock costs and space consumption costs. For this, we can refer to the values proposed by STIF, see the following tables.

Cost	Subway	Underground RER	Surface RER
Infrastructure cost (1)			
Civil engineering (A1)			
Lifespan (years)	50	50	50
Initial cost (million€/km)	79	141	34
Depreciation annuity (million€)	6,19	11,03	2,66
Line lenght (km) (2)	217,7	30,9	84,2
Traffic (million pkm) (3)	6014,9	2106,4	2282
Unit cost (€/pkm)	0,224	0,162	0,098
Heavy equipment (A2)			
Lifespan (years)	20	20	20
Initial cost (million€/km)	17	28	14
Depreciation annuity (million€)	1,48	2,45	1,22
Line lenght (km)	217,7	30,9	84,2
Traffic (million pkm)	6014,9	1985,3	2150,8
Unit cost (€/pkm)	0,054	0,038	0,048
Light equipement (A3)			
Lifespan (years)	10	10	10
Initial cost (million€/km)	17	19	8
Depreciation annuity (million€)	2,17	2,43	1,02
Line lenght (km)	217,7	30,9	84,2
Traffic (million pkm)	6014,9	1985,3	2150,8
Unit cost (€/pkm)	0,079	0,038	0,04
Infrastructure cost (€/pkm)	**0,357**	**0,238**	**0,186**

Figure 4.4.5. Estimation of infrastructure costs for public transportation networks in Ile-de-France

Source: RATP, 2013; STIF, 2015

Note: The same reasoning is used as for the fast road, considering the current cost of a km for each mode. Investment costs for infrastructure only make sense for our typical trips for the subway, the surface RER and the underground RER (STIF, 2001).

The length of the RER lines (115.1km) only includes the RATP's RER, because it can sufficiently reflect the infrastructure cost for the other SNCF RER sections.

According to the 2005 passenger travel count for Ile-de-France, 48% of RATP RER pkm are on the underground section, while 52% of pkm are on the surface section. In other words, there were 2106.4 pkm on the underground part in 2003 and 2282.0 pkm on the surface part according to the traffic volume is 4388.4 pkm in 2003.

The cost of rolling stock in Ile-de-France is estimated on the basis of the annual depreciation of PV on each of the networks excluding the inner-city buses (already included in operating costs). The unit cost is obtained by multiplying the depreciation annuity of a PV by the overall volume of the fleet, and relating this to the traffic expressed in terms of pkm. The estimation process is shown in figure 4.4.6.

Type	Subway	RER	Bus
Cost of rolling stock			
Lifetime of a car (years)	35	35	12
Cost of a vehicle (million€) (1)	1	2	0,2
Fleet volume	3510	1071	4000
Depreciation annuity (million €) (2)	0,074	0,147	0,0228
Total annual cost of the fleet (million€)	258,2	157,57	91,01
Traffic (million pkm)	6014,9	4084,1	2469,3
Cost of rolling stock per trip (€ /trip km)	**0,043**	**0,039**	**0,037**

Figure 4.4.6. Estimated rolling stock costs for PT networks in Ile-de-France

Source: RATP, 2013; STIF, 2015

Note: 1. The cost of a subway and *RER* car is the average purchase price (new) in € excluding tax and the cost of a bus car is the price with tax (*STIF,* 2005).

2. The depreciation annuity for a standard subway, *RER* or bus car (including renewal and residual values) is multiplied by the total number of PV in the *RATP* fleet and divided by the number of passengers * km of the network in question.

The calculation formula is as follows:

$$A = C_t * \left[\frac{1 - \frac{1}{1.08}}{1.08(1 - \frac{1}{1.08^n})} \right]$$

To estimate the costs of space consumption for buses, the method of calculation is identical to that used for the automobile, and a distinction is made between two-unit costs for space consumption related to the bus on a common lane or in a reserved lane. The relative parameters related to the estimation of space consumption are shown in Box 2 below. The hourly price per square metre depending on location is the same as that used for the cost of car space consumption.

Type	Paris	PC	GC
Cost of space consumption (1)			
Space consumption (m²/h/pkm)	0,45	0,47	0,74
Space consumption (m²/h/pkm) in UPT/ERW (2)	0,49	0,69	1,5
Land price (€/m²)	1650	820	330
Depreciation annuity (€/m²) (3)	115,63	57,47	23,13
Number of hours of occupancy per year (h)	3600	3600	3600
Hourly land cost (€/h/m²)	0,032	0,016	0,007
Cost of space consumption (€/pkm)	**0,014**	**0,008**	**0,005**
Cost of space consumption UPT/ERW (€/pkm)	**0,016**	**0,012**	**0,01**

Figure 4.4.7. Estimation of the costs of space consumption for buses in Ile-de-France

Source: STIF, 2015

Note: 1. Here we have chosen to allocate all this expenditure to PV, since PV in Ile-de-France represent 43 billion vkm, compared with nearly 148 million vkm for buses.
2. UPT/ERW: exclusive lane public transport
3. The lifespan is estimated at 50 years.

Assessing space consumption, part 2

According to the general formula of the traffic space-time consumption (TSC), we can give here the correlative parameters related to the bus in common lane and in reserved lane.

- The average lane width in the urban area is assumed to be constant, and set at 3.5 metres for the common lane and 4.5 metres for the reserved lane.

- The average speed per zone is 9km/h in Paris, 10km/h in PC and 12km/h in GC for the bus in the normal lane. In addition, the average speed for the bus in the reserved lane is assumed to be 1.5 times faster than the bus in the normal lane. (Héran, 2008).

- The bus occupancy rate can refer to STIF data (2005) for the average occupancy rate of buses, of which 27.2 passengers per 100 seats in Paris and 25.1 passengers per 100 seats in the suburbs (RATP buses) and 15.4 passengers per 100 seats in the suburbs (OPTILE buses). In other words, the bus occupancy rate can be assumed to be 19 passengers per bus in Paris, 17 passengers per bus in Paris and 11 passengers per bus in GC, if a bus has 70 seats available (based on 4 persons/m²). Moreover, in PC and our research, we assume that the occupancy rate of buses in reserved lanes is assumed to be 1.3 times higher than that of buses in normal lanes.

After estimating the investment cost related to the three main costs using the economic approach, we can put them together in figure 4.4.8 by noting that the investment cost related to the accounting approach is 1 to 9 times lower than that related to the economic approach.

Value	Subway	RER	Bus
Infrastructure cost per pkm	0,357	0,186 - 0,238 (1)	-
Cost of rolling stock per pkm	0,043	0,039	0,037
Cost of space consumption per pkm	-	-	0,005 - 0,016 (2)
Average investment cost (€/pkm)	**0,4**	**0,234**	**0,046**

Figure 4.4.8. Investment costs related to the economic approach to public transport in Ile-de-France

Source: STIF, 2015

Note: 1. 0,186 for surface *RER* and 0,238 for underground *RER*. Indeed, underground RER, which only occupies about 17% of the total length of lines in km (for *RER* A and B), is still concentrated in the Paris area, see *RATP* annual statistics, 2003. Including the bus in common and reserved lanes.
2. Including the bus in common and reserved lanes.

4.4.3. Comparison of the operating and capital costs of road use and public transport

The public cost related to the use of roads and public transport can be divided into two main costs (operating cost and capital cost) and evaluated in two approaches (the accounting approach and the economic approach). Therefore, we put them together in Figure 4.4.9 to compose the respective public cost for the Ile-de-France.

Indeed, the operating cost is undoubtedly simple and assured, because it can be traced in the annual public budget. As for the capital cost, we have proposed the two approaches related to the estimation of the capital cost. As we have already indicated, the accounting approach is adopted for estimating capital cost in both Ile-de-France and Yokohama city, because the road and transit infrastructure is relatively stable. The economic approach being related to the cost of land, it is rather reasonable to use it for capital cost estimations for networks under developments.

Public cost			Ile-de-France (€/pkm)		
Route			Paris	PC	GC
Operation		1.		0,016	
Investment	Recurring cost	2.		0,011	
	Development cost	3.	0,105	0,081	0,049
Public transportation			Subway	RER	Bus
Operation		4.	0,245	0,18	0,45
Investment	Recurring cost	5.		0,045	
	Development cost	6.	0,4	0,234	0,046
Value retained					
Route		7.		0,027	
Public transportation		8.	0,29	0,225	0,495

Figure 4.4.9. Operating and capital costs of road use and public transport in Ile-de-France

Source: RATP, 2013; STIF, 2015

4.4.4. Public performance of travel

Following the evaluation of the private and public cost, we can see that the total public expenditure is not entirely the responsibility of the public authorities, because there are also partial revenues related to fares and taxes.

In other words, if we aim to recognize the real public cost to be borne by public authorities, we must reduce the evaluation of the public cost indicated in this section by deducting additional public revenues, such as revenues related to fares, taxes, transport payments in Ile-de-France, etc. To do this, the public cost thus obtained is reduced by the private cost to be borne by the user or the employer through fares.

For government revenues from transport use, for example, tax-free fare revenues (fares for public transport use and on-street parking for motor vehicle use).

As for government revenues from transport use taxation, there are two parts: tax revenues from transport use include taxes on fuel, insurance, and so on. In addition, tax revenues from PT use are neglected, if tax revenues from VAT are not taken into account. In our research, we only take into account the specific taxes excluding VAT in the total cost of the trip.

In addition, in Ile-de-France, we also have to take into account the additional revenue related to the transport payment for public authorities, because this transport payment is borne by employers, as we presented the contribution to be borne by employers in section 4.5.

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Depending on the definition of the public return on user-related travel, this return can be divided into two parts: tax revenues and fare revenues.

Tax revenue is derived from the final consumers of transport through taxes (STIF, 2015). The main taxes and fines generated by the transport sector come from three sources: fuel taxes, vehicle taxes, and fines. In addition, we leave VAT out of our travel cost account.

Fare revenue excluding taxes, such as revenue from public transport fares and motor vehicle parking. The amount of revenues and taxes on the ownership and use of vehicles determines the public revenues related to investment and operating activities, which are deducted from public expenditure, making it possible to estimate the number of subsidies or, on the contrary, the profits of the State and local authorities.

Fare revenue
Direct revenue from the sale of titles comes mainly from households. We first calculate the revenue per pkm according to the networks. RATP's cost accounting gives us a breakdown of total traffic revenue by network.

Type	Value			
Total ticket receipt (€)	Subway	RER	Bus	Total
Total traffic revenues (million€)	671,72	349,82	539,96	1561,5
Traffic (million pkm) (1)	6014,9	4084,1	2469,3	12568,3
Unit revenue per vkm (€/pkm)	**0,112**	**0,09**	**0,22**	**0,12**

Figure 4.4.10. Unit revenues according to the modes of public transport in Ile-de-France
Source: RATP, 2003 and STIF, 2005

Note: 1. Including SNCF and RATP RER trains

For the parking revenue for PV use, we distinguish in three cases:
- An average parking cost, for which we include the total expenditure on parking in Ile-de-France in the passenger transport account (approximately '1040 million in 2003), which we relate to the total number of vkm and pkm. (0.023 €/vkm and 0.018 €/pkm) Cases of free parking.

- Cases of full rate parking. The parking time is assumed to be 2 hours, and in this case the parking prices used in the passenger transport account are as follows: 2 euro/hour in Paris; 1 euro/hour in the Lesser Krona and free in the Greater Krona, (see STIF, 2005).

In our research, we refer to the revenue related to the average parking cost in our total travel cost account.

Tax revenues

In Ile-de-France, we can refer to STIF data on taxes collected on passenger transport expenditure in 2003, see the following table, which shows the tax revenues related to agents (State, region, local authorities and STIF) for the use of PV.

(In million €)	State	Region	Loc. author.	Total
Private vehicles				
TIPP (fuel taxes)	1760	-	-	**1760**
Taxes on insurance and driver's license	635	-	-	**635**
Company private vehicle tax	435	-		**435**
Car registration	218	236	-	**454**
Vignette (pollution tax)	-	-	39	**39**
Fines	-	37	37	**74**
Total (excluding VAT)	**3 048**	**272**	**76**	**3 396**

Figure 4.4.11. Tax flows related to passenger transport in Ile-de-France

Source: STIF, 2015

For automobile travel, the tax yield on the trip is estimated from the amounts shown in the passenger transport account for the TIPP for private and commercial automobiles, plus the sum of other taxes (vignette and vehicle registration tax). The following table refers to revenue per pkm.

Types of taxes	Amount (€/pkm)
Motor vehicle	
TIPP (fuel taxes)	0,032
Insurance taxes	0,012
Company private vehicle tax	0,008
Car registration	0,008
Vignette	0,0007
Fines	0,001
Tax yield per travel km (€/trip km)	**0,0617**

Figure 4.4.12. Tax performance of automobile travel

Source: Estimation by the author based on STIF, 2015

As for tax revenues related to the use of public transport, they are practically nil as far as passenger charges are concerned (excluding VAT).

On the other hand, we have to take into account additional revenues, such as the transport payment, for public authorities in order to relieve the public financing that is the responsibility of public authorities.

In fact, real public financing linked to public authorities (including public transport companies and the State/Region/Department) accounts for only 32% of the total public cost in Ile-de-France (6.85 billion in 2003), see the following figure. As for other revenues related to the financing of public transport, 26% are related to households (ticket fare revenues) and 42% to employers (transport payments).

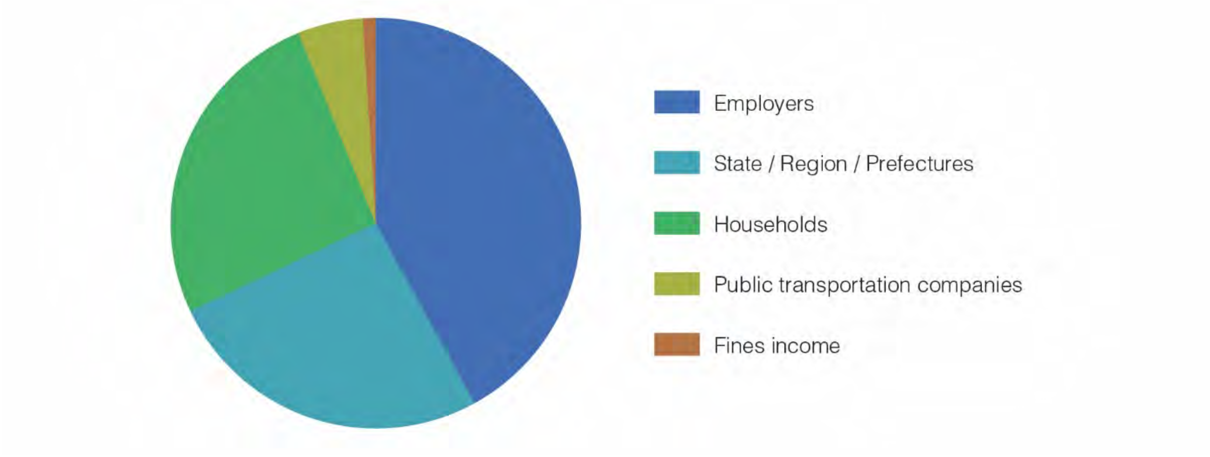

Figure 4.4.13. Distribution of public transport financing

Source: STIF, 2005

Indeed, for household related revenues, we have already proposed the fare revenues related to ticket prices. Therefore, we do not count this revenue here. On the other hand, we have to consider the contributions of employers, who contributed €2,89b in 2003. To do this, we can estimate that the additional public revenue linked to the employers' contribution for the use of public transport in relation to the pkm is €0,119/pkm in Ile-de-France, of which €0,094/pkm is linked to the transport payment and €0,025/pkm is linked to the reimbursement of subscriptions.

Overall, the net public cost to be borne by public authorities for the use of public transport is the gross cost related to operating and investment expenditure less fare revenue (tickets) and the partial transport payment (relating to the private cost account). Moreover, in relation to total public transport traffic, we can estimate the net public cost per pkm.

4.4.5. Findings

Depending on the results of the calculations, we can put all the public costs related to modes a. In addition, to estimate the public cost of bicycle use, only the public cost of road use is included. To do this, we can first assume that the public cost for the bicycle mode is 0.25 [17]times that of PV mode. In addition, the UITP report indicates that the public cost for the motorcycle mode is half the cost of land in circulation and half the cost of parking for PV mode. In this case, we can assume that the public cost for the motorcycle mode is half the cost of PV mode. As for the public cost of taxis it is assumed to be the same as for PV for traffic, the public cost of parking in taxis is almost zero. In the figure 4.4.14, we first present the cost of operating and capital expenditure per pkm.

[17] According to the UITP report, it is stated that space consumption in traffic by car is 2.5 times more than by bicycle. In addition, parking space consumption is 6 times higher than by bicycle.

In both areas, this cost is assessed using the accounting approach. Then, we also show the net public cost (real public cost), which is the total cost related to operating and investment expenses minus the public return related to fare and tax revenues. We have already presented the relationship between gross capital and operating cost, net public cost, and public return to avoid double counting in the total travel cost model. Thus, we can show the relationship: Net public cost is gross cost minus public performance.

Type (€/pkm)	**Zone**	**Bicycle** (1)	**Moto.** (2)	**Car**	**Bus**	**Subway**	**RER**
Gross cost (4)	IDF	0,007	0,013	0,027	0,495	0,29	0,225
Public performance	Park. rates	-	-	0,018	0,22	0,11	0,09
	Tax rev.	-	0,031	0,062	0,072 (3)	0,072	0,072
Net public cost	IDF	0,007	-0,018	-0,053	0,203	0,108	0,063

Figure 4.4.14. Net public cost according to modes in Ile-de-France

Source: Estimation by the author based on STIF, 2015

Note: 1. It is assumed that only a quarter of the operating and capital cost of an automobile is involved.
2. It includes half of the cost of operating and investing in automobiles.
3. This revenue "0.072" means that the revenue related to the transport payment is noted in the private cost account.
4. Gross cost per pkm is the cost of operating and capital expenditures for the use of roads and public transport.

4.5. External costs

Travel also generates external costs, which are of some importance, especially in the city. Button (1993) provides a definition of externality:

"The concept of externality means that men's activities influence the well-being of other men, yet give rise to neither compensation nor remuneration."

The European Commission has also proposed the following definition:

"External costs are those costs to society that, without political intervention, are not taken into account by transport users."

Transport activities can not only influence producers and users, but also produce effects for other humans, this is called the transport externality. The cost caused by the effect of the externality is called the external cost. In addition, Friedrich and Bickel (2001) have also defined the environmental costs and benefits caused by the activities of some people influencing others, without giving rise to payment. The European Union and many other institutions propose economic evaluations of external costs.

In fact, motorized vehicle traffic causes all kinds of nuisances: air pollution, noise, accidents, the greenhouse effect and congestion, which are increasingly badly borne by the population. These negative effects on the environment are not limited to urban areas: the contribution of transportation to greenhouse gas emissions, mainly due to automobile traffic, has increased rapidly, while most other sectors of the economy have managed to control their fossil fuel consumption, mainly in developed countries. Road congestion seriously threatens the freedom of movement that the automobile is supposed to provide and penalizes surface public transport that is hampered by traffic jams.

As part of study led by OECD about the environmental implications of support to the energy sector, teams from the United States, Japan, and France analysed the overall costs of the road transport system, their coverage by specific revenues, and the effects of a strategy of full cost coverage by specific revenues in their respective countries (Orfeuil, 1997).

The evaluation of external costs has given rise to numerous studies (UITP, 1999; CERTU, 2000; Boiteux, 2001) whose results may differ significantly depending on local conditions, but also on the methods used, see the comparison of external cost results in this section. According to the UITP report in 1999, an annual loss to the economy of the European Union countries was reported to be in the order of 6% of GDP, or €360b. The external cost to the community is very high, see figure 4.5.1.

External cost category	GDP (%)	External cost category	GDP (%)
Noise	0,3	Accidents	2
Local air pollution	0,4	Congestion	2
Greenhouse effect	>1		

Figure 4.5.1. External costs of transportation relative to GDP

Source: UITP, 1999

According to the INFRAS/IWW report (2004), the total external costs excluding congestion costs reached €650b in 2000 for 17 countries in the EU, with climate change as the first negative effect (about 30% of the total external cost). On the other hand, two thirds of the external cost is caused by passenger transport and one third by freight transport. We indicate the relative proportion of external costs in the following table:

Category	External cost (%)	Category	External cost (%)
Accidents	24	Noise	7
Air pollution	27	Nature and landscape	3
Climate change	30	Urban effects	2
Downstream and climate change	7		

Figure 4.5.2. Proportion of external transport costs in European Union

Source: INFRA/IWW, 2004

We can see that the most important external costs (excluding congestion) are concentrated on three costs: accidents, air pollution and climate change (81% of the total external cost), in addition there is another 7% of the total external cost related to climate change coming from downstream and upstream traffic.

In addition, we can indicate the external cost of the modes (car, bus, motorcycle and rail) according to INFRA/IWW data in the following figure. Therefore, we can see that the motorcycle has the highest external cost compared to the others, because the cost of accidents is very expensive. On the other hand, the external cost of public transport is much lower than that of PV.

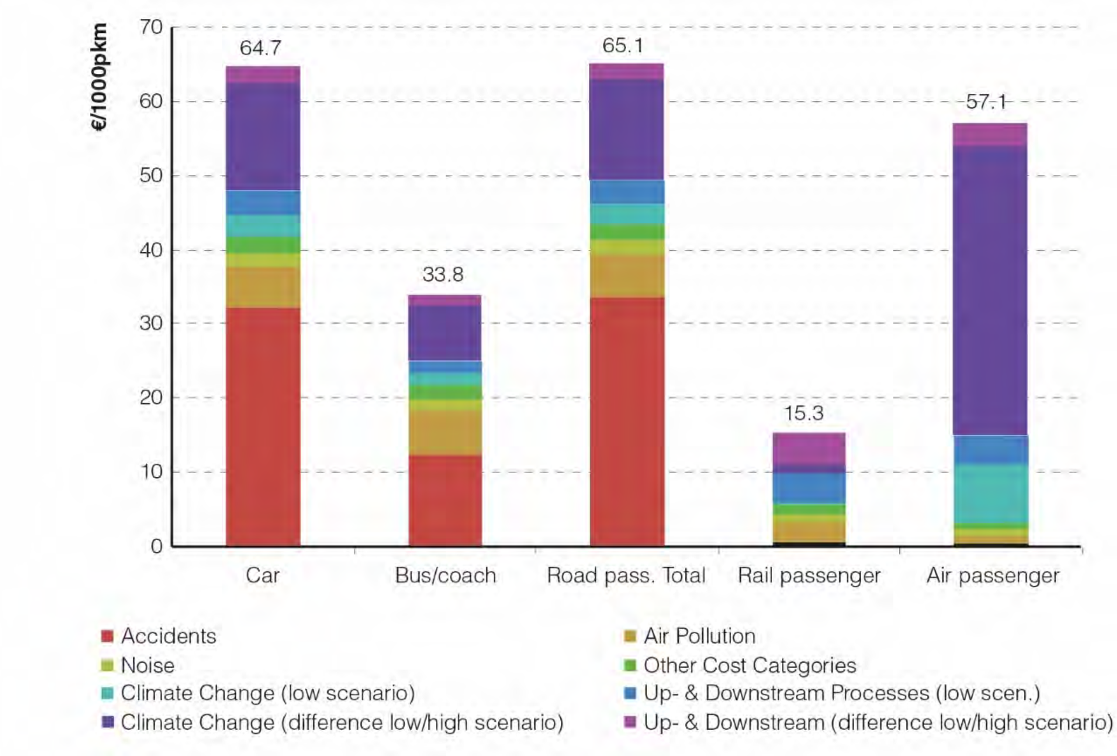

Figure 4.5.3. Average external costs by passenger mode in Europe

Source: INFRAS/IWW, 2008

Note: Other cost categories: Costs for nature & landscape, biodiversity losses (due to air pollution), soil and water pollution costs,
additional costs in urban areas. Data do not include congestion costs.
Data include the EU-27 with the exemption of Malta and Cyprus, but including Norway and Switzerland.
Differentiated cost for rail: Rail Electric: 12.0 €/1,000 pkm, Rail Diesel: 34.1 €/1,000 pkm

In addition, we can also cite data from Litman (2002) to compare the external costs of modes in North America. Although the external cost factors are not equivalent in the VTPI and INFRAS/IWW research, they are still identical. Here, the cost of air pollution is dominant, especially for the motor vehicle modes. In addition, the external cost for the motorcycle mode is higher than for PV mode, where the noise cost is the first cost and the air pollution cost is the second highest compared to the other costs (but it does not take into account the cost of accidents). The bus has the highest external cost here, because it has two reasons: it considers a low bus occupancy rate and it uses the diesel engine. On the other hand, the diesel PV is banned in North America.

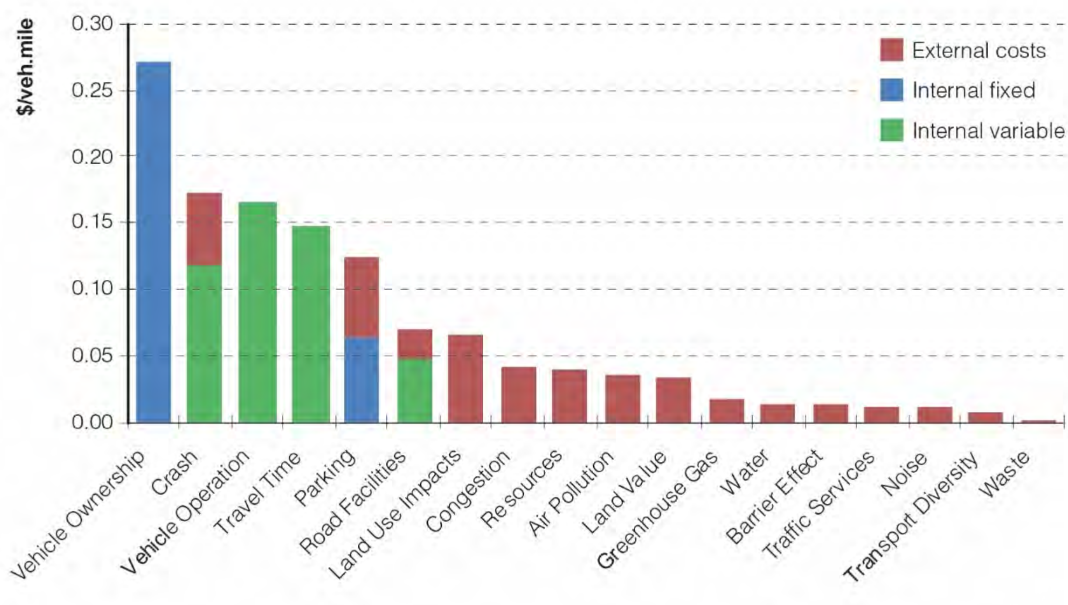

Figure 4.5.4. Average costs of automobile

Source: VTPI, Litman, 2009

On the other hand, the cost of climate change, rather the cost of the greenhouse effect, is the most important in the total external cost for the INFRAS/IWW study. However, it is not included in the VTPI research. On the other hand, we can observe that the cost of land for the public transport mode is also another important cost.

The Eurovignette 3 report has just been published in 2008, it evaluates the external costs (noise, accidents, air pollution, climate change, energy production and nature/landscape) for PV in petrol/diesel and the train in diesel/electric.

This research does not provide a very coherent view of external costs. We therefore need to propose our own estimates by drawing inspiration from another recent research listed in the following table.

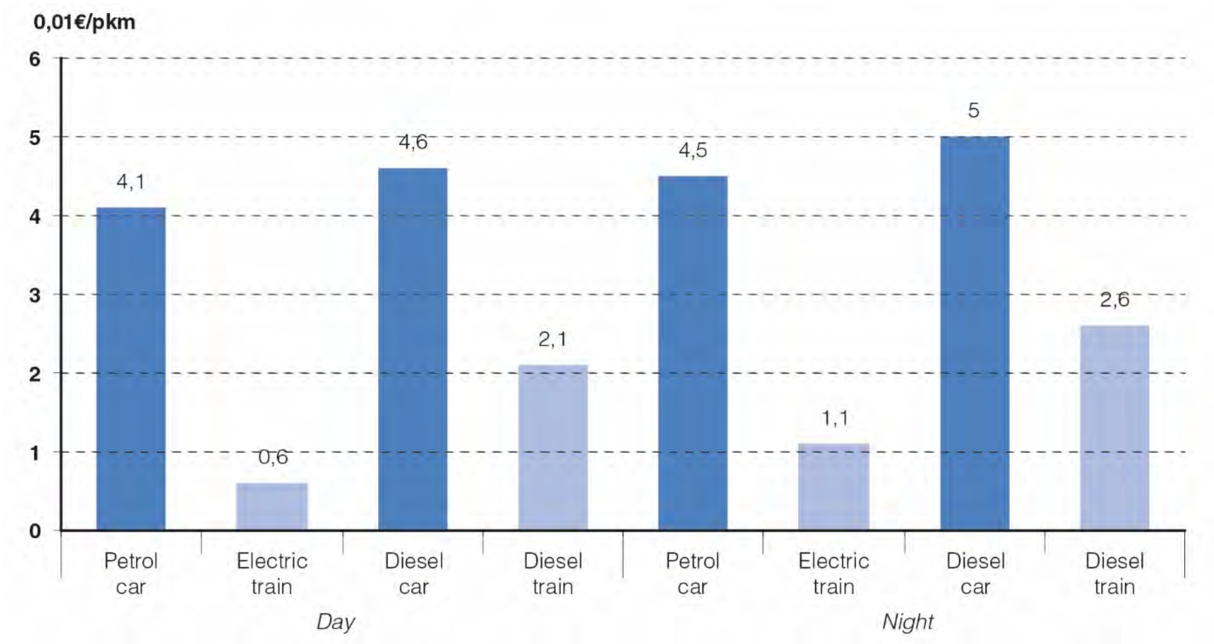

Figure 4.5.5. Comparison of rail-road passenger transport in urban areas

Source: Eurovignette 3, 2008

Note: The average occupancy rate of PV is 1.65 person/car and of the train is 96 passengers/ram.

Publication	Main objective	Scope of cost estimates
Boiteux (1994 ; 2001)	Takes into account the impact of projects on the environment and safety.	Based on external cost evaluation methodologies, unit values to be attributed to four external costs in the perspective of infrastructure development.
INFRAS/IWW (2000)	Estimation of external transport costs in Europe.	Evaluation of average and marginal external costs, at the country level and for some areas.
VTPI (2002)	Estimate and comparison of total costs according to mode of transportation.	Total travel costs for 11 modes of transport and 2 transport geographical conditions (urban and
UNITE (2003)	Aims to define the concept of transport benefit based on the calculation of marginal costs.	Methodologies to estimate marginal costs for specific situations.
HEATCO (2006)	Develops a harmonious standard average evaluation external cost assessment for UE transportation projects	Assessment of average external costs on congestion, the impact on health caused by pollution and noise and also infrastructure costs.
EUROVIGNETTE 3 (2008)	Provides a valuable tool for the European Commission to assess external costs	It is a matter of squaring the circle: finding a formula that satisfies the railways without alienating the roads, which will eventually have to

Figure 4.5.6. Characteristics of correlative searches

Source: Created by the author

Methods for the evaluation of external costs

The evaluation of external costs is carried out according to different methods: on the one hand, the cost of avoidance is estimated as an economic cost for the community, considering that the avoidance of nuisances requires capital expenditure which, because it is not productive, generates a devaluation. The evaluation results from a discounting calculation, which estimates the annual cash flow required to balance the cost of avoiding investments and operating costs (people, maintenance) on the basis of the discount rate. This method is often used to monetize the cost of noise. On the other hand, the cost of damage, which involves evaluating the cost of the impact on society of the damage caused by the nuisance. This method is typically used for the monetary evaluation of accidents and congestion. In addition, two working groups on the evaluation of investments in transport projects have proposed monetary evaluations of pollution and the greenhouse effect using other monetarization methods. All methods suffer from great difficulty in interpreting the concept of "optimum from pollution", i.e., to search for the point equalizing the marginal costs related to damages and strategies to avoid these damages. Even a partial review of the literature on transport costs gives a certain sense of unease for two essential and partly related reasons (Orfeuil, 1997):

- the dispersion of estimates is very important, because the concept themselves (costs, valuation methods) are not always precisely defined.
- the level of the estimates is not independent of either the sponsors of the studies or the general media context at the time they were undertaken.

As a result, we are encouraged to make our own estimates. The challenge is less to arrive at the best value than those in the literature than to clearly set out the terms of the approach, the necessary hypotheses, etc. Therefore, we aim first to integrate the results evaluated of external costs by the research concerned and at the same time try to propose a reasonable value for external costs, although the values related to externality are varied. In fact, external costs, which really include many components, are still difficult to quantify precisely. However, we still need to consider these external costs in our total travel cost analysis model in order to fully reflect the distribution of correlative costs in a daily trip. Therefore, we will propose external cost estimates in the following paragraphs for air pollution, greenhouse effect, noise, congestion and accidents.

4.5.1. Cost of air pollution

Air pollution is mainly assessed through its impact on human health. It is therefore directly related to the value of human life. It is the result of many factors that are not limited to the transportation sector alone: heating, solvent evaporation, industrial emissions, smoking and natural phenomena are all involved. In addition, not to mention the habitat itself, where pollution sometimes exceeds that of the outside environment, pollution can affect a limited geographic area or, on the contrary, affect an entire region. In order to use monetary values for the transport sector for profitability calculations, research has limited its scope to transport pollution and its impact on health. To justify the values proposed at the conclusion of this section, we review the main results obtained in studies on the subject in order to propose a methodology for analysing the appropriate value.

4.5.1.1. Air pollutants emitted by vehicles

Emissions from internal combustion engine vehicles include exhaust fumes, crankcase gases, evaporation of fuel stored in the tank and admitted to the carburettor, the mixing of dust, and particles released by tire and brake wear. Gasoline vehicles emit the following air pollutants: carbon monoxide (CO) and hydrocarbons (HC) or more precisely volatile organic compounds from incomplete combustion; nitrogen oxides (NOx) formed at high combustion temperatures, mainly from the oxygen and nitrogen in the air of the combustion medium; more or less fine particles, etc.

Cars running on compressed natural gas and liquefied petroleum gas (LPG) emit less HC and CO in the exhaust gases, as combustion is more complete; nitrogen oxide emissions are of the same order of magnitude as those of gasoline-powered cars. Diesel engines have better combustion efficiency. Vehicles equipped with them are much less polluting than their gasoline counterparts; at equal power, CO and HC emissions are much lower (28 and 13 times lower); NOx emissions are similar, with lower emission temperatures. On the other hand, they emit fine particles containing polycyclic organic compounds (a group of substances with genetic toxicity), sulphur dioxide (SO2), due to the presence of sulphur in diesel fuel, and larger quantities of aromatic hydrocarbons, which have an unpleasant odour and harmful effects on health, some of which are known to be carcinogenic. In the United States, then in Europe, and today in many other countries, standards strongly limit these emissions for new vehicles.

These pollutants can have the following direct and indirect effects:
- health effects (irritation of the respiratory system, eyes etc.; acute toxic effects; mutagenic or carcinogenic effects, detrimental effects on the defence mechanisms against infections;
- environmental damage (fouling of materials, corrosion, acidification of soil and surface water, forest dieback, etc.);
- nuisances (odours, mist effect).

4.5.1.2. Literature review

Knowledge has evolved profoundly in recent years, both in terms of epidemiological studies on the health effects of pollution and the dispersion of pollutants. These studies have highlighted the impact of long-term effects, both in terms of mortality and morbidity. As a result, the health costs of pollution are today estimated to be significantly higher than in the early 1990s, although emission levels are decreasing. The various studies available present significant diversity in their methods and in their field of analysis, which generates a significant heterogeneity of results. For example, long-term effects are not always taken into account, and the comparison of different results, too often expressed very broadly as a percentage of GDP, therefore presents difficulties. The Planco (1990) study uses a cost of air pollution, the minimum being obtained by estimating the damage (health, vegetation and buildings), the maximum being obtained by a study of willingness to pay for clean air in large conurbations on the basis of stated preferences. The damage estimation gives about 48% of the costs for health, 37% of the costs for nature and 15% for buildings. The average of the estimates reviewed by Quinet (1993) is 0.36% of GDP, with 0.12% for health, 0.08% for buildings and 0.16% for vegetation. Lamure and Lambert (1994) arrive at a result close to 0.4% of GDP. The Finnish administration (Lamure, 1994) estimated the cost of air pollution at 19% for human health, 15% for vegetation and forests, 16% for buildings and 50% for the greenhouse effect.

The greenhouse effect is today isolated from the polluting costs and is the subject of its own estimation. In addition, we have also collected other studies at the regional or national scale on the evaluation of the cost of pollution such as the study at the regional scale CERTU, UITP and at the national scale INFRAS, VTPI etc., see the following table. For this, we can see that the estimated pollution value proposed by the studies is still varied, see the following table. In addition, we can also observe that the value at the regional scale is obviously higher than the value at the national scale, because the density of motorized vehicle traffic in the urban area is higher than that at the national level.

(€pkm)	Regional level				National level		
Study	Boiteux	STIF (6)	CERTU (3)	UITP	INFRAS /IWW (4)	VTPI (5)	UNITE
Years	2001	2003	2000	1999	2000	1996	2003
Automobile (1)	0,023	0,018 - 0,006	0,023	0,009	0,01	0,04	0,0012- 0,0025
Motorcycle	-	0,103 - 0,036	0,133	-	0,003	0,06	-
Bus (2)	0,014	0,012 - 0,004	0,005	< 0,001	0,017	0,05	-

Figure 4.5.7. Value attributed to the impacts of air pollution according to studies

Source: Created by the author

Note: 1. PV occupancy rate is *1.28%*.
2. The bus occupancy rate is *17.8* in 2002 passenger/vehicle (pkm / car-km) [3] The unit cost per type of vehicle and urban area.
3. The average cost of air pollution in Europe (17 countries)
4. Estimated 1996 US$ value per vehicle-kilometre
5. Value in red for the Paris and Petite couronne zones; and the value in blue for the Grande couronne zone.

4.5.1.3 Estimated value

In Ile-de-France

The work of the Regional Air Quality Plan (PRQA) has shown the contribution of road transport to overall pollutant emissions in Ile-de-France: 53% for Nitrogen Oxides (NOx), 34% for NMVOCs, 43% for Carbon Monoxide (CO). Air pollution, excluding the greenhouse effect, comes from several emissions with different ranges. Two of them can be distinguished (Boiteux 2001) :

Regional pollution due to nitrogen oxides which, at the mercy of the winds, affect inhabited areas regardless of the place of emission.

Local pollution: hydrocarbons, carbon monoxide and particles have a local action; their harmfulness is reduced in the open country and only really appears in urban areas.

National standards for valuing the external costs of passenger and freight transport can be established (Boiteux, 2001). The "STIF travel accounts" report uses these standards to set the value of externalities, using, where relevant, the values (noise, pollution) for dense urban areas. This method does not seem to us to go to the end of the reasoning, because dense urban areas begin at a density threshold (420 inhabitants/km²) that is very much exceeded in Ile-de-France, which has 19% of the French population in just over 2% of the territory. The costs of pollution and noise are a function of both traffic and the number of people exposed, which has consequences for the distribution of costs in Ile-de-France and the major French cities, and, within Ile-de-France, between Paris, the inner suburbs and the outer suburbs.

In short, the same kilometre driven in a vehicle does not have the same impact depending on whether it is driven in the centre of Paris, in a remote suburban commune or even in the centre of a large provincial city, because the number of people exposed to pollution or noise during this trip is very different in the 3 cases.

To carry out our estimates, we start from the values recommended by the Boiteux report for the dense urban area (Paris and inner suburbs), while for the outer suburbs, we can refer to the value for the diffuse urban area.

0,01€/100vkm	**Car**	**Motorcycle**	**Bus**
Dense urban	241	1108	2273
Urban diffuse	83	794	382

Figure 4.5.8. Value attributed to air pollution impacts

Source: Boiteux, 2001; STIF, 2005

In fact, standards for two-wheelers have evolved considerably and, according to ADEME, the emissions of motorized two-wheelers are now comparable to those of cars. A cost of 241 centimes is therefore charged for motorized two-wheelers as for PV in dense urban areas. The cost of pollution is half the cost of local pollution (in proportion to the density of the areas crossed, whether in the centre or the suburbs) and half the cost of regional pollution, in proportion to the densities of the urban areas as a whole.

The areas corresponding to dense urban in the sense of Boiteux are characterized in the table below from the point of view of residential densities. There is a difference of 1 to 40 between the areas of the lower and higher density of the dense urban area, which cannot fail to have an impact on the costs of pollution and noise. The same type of difference would be found if we were interested in pedestrian density. For example, there are daily pedestrian travel densities varying from 28,000 per day per km² in Paris, 4,000 per day per km² in the centres of conurbations with more than 300,000 inhabitants, 2,000 per day per km² in the centres of conurbations with 100,000 to 300,000 inhabitants and 500 per day per km² in the suburbs of these conurbations.[18]

18 Calculations by Orfeuil based on "La mobilité régulière et la mobilité locale", Madre et Maffre, INSEE, 1997.

	Ile-de-France	(1) Big agglomerations	(2) Medium agglomerations	(3) Small agglomerations
1 **Downtown**				
Density (hab/km²)	20500	4100	3100	1700
Automobile traffic (billion km/year)	3,6	6,2	11,3	22
2 **Suburbs**				
Density (hab/km²)	3300	900	600	450
Automobile traffic (billion km/year)	12,9	14,6	15	10,7
3 **Downtown + suburbs**				
Density (hab/km²)	8100	1330	1130	850
Automobile traffic (billion km/year)	16,5	20,8	26,3	32,7

Figure 4.5.9. Distribution of automobile traffic and population densities by region

Source: Orfeuil, 1997

Note: (1) Agglomerations with more than 700 000 inhabitants
(2) Agglomerations between 300 000 and 700 000 inhabitants
(3) Agglomerations between 100 000 and 300 000 inhabitants

We therefore accept the unit values prescribed by the Boiteux report for PV for all of these dense urban fabrics, but we consider that the allocation between territories is made on a pro rata basis according to densities. Therefore, we aim to present the evaluation of the cost of pollution in two parts: one is regional pollution and the other is local pollution.

To evaluate the cost of regional pollution, we first present the following general formula.

$$\sum(D_i * T_i * \mathrm{a}) = \sum \mathrm{T} * \mathrm{V}$$

With:
D_i is the population density for region i (related to line 3);
T_i is PV traffic for region i (related to line 3);
a is a regional pollution coefficient;
ΣT is the total traffic (related to line 3);
V the assigned value, here is half of the total value Boiteux assigned (0.0241/2) €/vkm (regional components).

According to the above formula, we can first obtain the coefficient "a" (5.303E-06), then we can estimate that the total cost of regional pollution for Ile-de-France is €0,708b $(D_i * T_i * a)$ Compared to the traffic in Ile-de-France T_i, the cost of regional pollution is 0.043 €/pkm.

In addition, we need to estimate the cost of local pollution that is affected by zone. First of all, we use the same general formula as above. But we consider the parameters related to the central and suburban areas (line 1 and 2). For this, we can obtain that the coefficient "a" is 4.812E-06. Then, we can respectively estimate the cost of local pollution by zone (centre and suburbs). The results are shown in the following table.

€/vkm	Centre (Paris)	Suburbs (PC)	Suburbs (GC)	Average (IDF)
Regional pollution	0,0429		0,0083	0,037
Local pollution	0,355	0,204		
Cost per vkm	0,141	0,059	0,009	0,037
Cost per mileage	**0,111**	**0,046**	**0,007**	**0,029**

Figure 4.5.10. Results of the evaluation of the cost of pollution in Ile-de-France

Source: Created by the author

As for the cost of pollution for two-wheelers relative to the pkm, we can assume that it is identical to the cost of pollution for the use of PV. For the cost of bus pollution per pkm, we can estimate it according to the weighting related to the value assigned to PV and the bus and to PV and bus occupancy rate. That is, the cost of pollution per area for bus use is 0.6 times lower[19] than for PV use.

€/pkm	Centre (Paris)	Suburbs (PC)	GC	Average (IDF)
Cost per mileage	**0,067**	**0,028**	**0,002**	**0,027**

Figure 4.5.11. Results of the evaluation of the cost of bus pollution in Ile-de-France

Source: Created by the author

We will use in our estimates the values appearing in the lines "pkm" in figures 4.5.10 and 4.5.11. They are significantly higher than those proposed for STIF.

4.5.2. Noise

Transportation noise is one of the most intensely felt nuisances by populations, whether urban or rural and close to major infrastructure. Its importance is growing due to an increasingly acute sensitivity to this nuisance, and to the continuous growth of passenger and freight traffic. In addition, road traffic is a very important source of noise. As the unit costs to be used for noise differ according to exposure levels and periods of exposure, other issues arise such as differentiation of the values to be used for different modes of transport, consideration of long-term health effects, problems of noise assessment upstream of projects, and the treatment of uninhabited areas.

[19] The assigned value per vkm for bus use in the dense urban area is 9.4 times higher than for car use (2273/241), furthermore, we have to consider the weighting between bus and car use according to the occupancy rate (20 passengers/bus and 1.28 passengers/car).

4.5.2.1. Literature review

The attempt at a monetarized assessment of transport noise was initiated by the General Planning Commission (*Commissariat Général du Plan*) in their 1994 report. The method chosen, which was only of an order of magnitude, was based on an overall estimate of the cost of noise at the national level, as a percentage of gross domestic product (0.3% of GDP), which is induced by reference to foreign countries. In addition, Quinet (ECMT 1993) lists 22 estimates ranging from 0.02 to 2% of GDP. And Lamure and Lambert (1994) find an average value of 0.2% of GDP in the international literature. The INFRAS/IWW study results in a much higher estimate of the costs of road transport noise in 2001, with €7b for France.

The report by Boiteux (2002) proposes a direct method for assessing the value attributed to noise in 2000. It is proposed that a monetary value that expresses the damage suffered by local residents be recorded as a cost assigned to a project. This cost is defined by the depreciation of average rents per square meter of occupied surface area exposed to noise levels exceeding a certain threshold. The reference rent chosen is 5.49 € per square meter per month (1996 value). These values will grow annually in line with the GDP. These values are also modulated to take into account the vocation of the areas concerned and the different health effects of daytime and night-time noise. The authorized daytime noise level in residential areas is 60 decibels.

Basic calculation	Sound exposure (dB)	55-60	60-65	65-70	70-75	> 75
	Depreciation/dB (%)	0,4	0,8	0,9	1	1,1

Figure 4.5.12. Noise attributed value

Source: Boiteux, 2001

In addition, the STIF (2001) report indicated that the reduction of noise pollution can be achieved by different techniques:

- Action at the source: regulations, stemming from European directives, currently set the maximum noise level for new vehicles at 71 dB (A). Action at source on vehicles allows a gain of about 3 to 5 dB (A) in vehicle emissions. The investment cost is about 5% of the average cost of a vehicle.
- An action on pavement surfaces: the porous asphalt provides a gain of 5 dB(A) on main roads. Its cost varies according to the number of lanes. It is 228.7x103 € for 1km of 2-lane road (i.e. 7m wide). A better insulation of the facades provides a gain of about 15 to 20 dB(A). The average cost per dwelling is about 2439 €. The investment cost depends on the number of dwellings per km of lane.

The noise shield construction allows a gain of 10 dB(A) on average. The investment cost amounts to 1.94 million € per km for a screen 3 to 4m high, installed on each side of the road, i.e. about 2 to 3% of the cost of building 1km of road. For this purpose, we present these estimation results on the noise proposed by the 8 studies in the following table.

(€/pkm)	Regional level				National level			
Study	STIF	UITP	CERTU	Boiteux (4)	INFRAS /IWW	IFEN	ITS (1)	VTPI (2)
Years	2003	1999	2000	2000	2000	2007	2001	1997
Car	0,0095 (3) 0,0095 0,0032	0,01 – 0,025	0,009	0,009	0,0052	0,0031	0,0009 (5) 0,0004 0,0002	0,006 – 0,001
Motorcycle	0,069 - 0,023	---	0,072	0,072	0,016	0,0031		---
Bus	0,0113	0,002 – 0,003	0,001	---	0,0013	0,0002		0,005 – 0,001
Rail	0,004	0,002 – 0,003	0,059	---	0,0039	----	0,0006 – 0,006	0,003

Figure 4.5.13. Regional and national noise values

Source: Created by the author

Note: 1 The unit cost of noise per vehicle kilometre for the city of London
2 The city of Boston.
3. In red colour, the value is estimated in the central zone (Paris), in black colour is the small crown and the blue colour is for the big crown.
4. Estimated values based on noise cost estimates from the National Passenger Transport Account, traffic and noise equivalence coefficients.
5. In blue colour is the estimated value for the central London area; in black colour is the noise value for the inner suburbs area; in red colour is the estimated value for the rural area.

4.5.2.2. Estimated value

In Ile-de-France

The Boiteux report, on which STIF bases its estimate, proposes differentiated values for the cost of noise per vkm of 1.23€ per 100vkm in dense urban areas and 0.41€ in diffuse urban areas.

0,01€/100vkm)	Car	Motorcycle	Bus
High-density urban areas	123	736	614
Low-density urban areas	41	245	205

Figure 4.5.14. Value attributed to noise impacts

Source: Boiteux, 2001; STIF, 2005

The main purpose of the *CGP* report is the adoption of standards for new investments, particularly in the countryside, which explains why its treatment of urban areas is rather sketchy. In order to assess the impact of noise on the population a little more precisely, we can start from two simple ideas: the higher the noise level, the greater the impact, and the greater the number of people exposed to it. In other words, since noise is a very local nuisance, the contribution of a vkm to the social cost of noise on a territory must be proportional to the density of exposed people (which gives the number of people concerned within a radius around the point of emission) and to a local noise nuisance level indicator.

If one accept the national estimate of the cost of noise (4.0 billion, of which 2.55 billion is attributable to personal vehicles), then a method must be found to define the nuisance weight of one kilometre travelled by a vehicle according to the territory over which this distance is travelled.

We performed two tests by weighting each kilometre travelled by the product of the population density of the area and the vkm density, and then by the product of the population density and the logarithm of the traffic density (since decibels are a logarithmic function of noise emissions). In both cases, we obtain a weight of noise nuisance for the whole of Ile-de-France that is much greater than its mere weight in traffic, and a weight of Paris in Ile-de-France that is out of all proportion to the weight of Paris traffic in Ile-de-France traffic. As an example, the second approach contributes to attributing 58% of the national social cost of noise to intramural Paris and 79% to the whole of Ile-de-France (i.e. €2b, compared with €380m for STIF).

	IDF			A. +700 (1)			A. 300_700 (2)			A. 100-300 (3)			A. -100 (4)		
	Vkm	Den.	DT	Vkm	Den.	DT	Vkm	Den.	DT	Vkm	Den.	DT	Vkm	Den.	DT
Downtown	3,6	21	34,3	6,2	4,1	13,2	11,3	3,1	11,8	22	1,7	8,6	40	0,2	0,8
Suburb	12,9	8,1	16,8	14,6	0,9	4,7	15	0,6	4	10,7	0,4	2,2			
Periphery	26,5	0,9	2,2	3,3	0,1	0,5	6,4	0,1	0,5	9,7	0,1	0,4			

Figure 4.5.15. Distribution of private vehicle traffic and population densities by region

Source: Estimation by the author from the EGT, 2011

Note: 1. Agglomerations with more than 700 000 inhabitants
2. Agglomerations between 300 000 and 700 000 inhabitants
3. Agglomerations between 100 000 and 300 000 inhabitants
4. Agglomerations with less than 100 000 inhabitants

$$a * \sum D_i * \log_{10}\left({DT_i}/{0,4}\right) = CB_{national}$$

With:
D_i is the population density for region i
DT is the traffic density for the region i
a is a noise coefficient
$CB_{national}$ is the cost of national noise (€2.55 billion)

Therefore, we can calculate that the total density * $\log_{10}(DT/0.4)$ is 69.40 billion, in addition, the noise coefficient “a” is 0.036744 (2.55 divided by 69.4).

	Vkm	Noise cost	Noise cost/vkm	Noise cost/trip-km
Paris	3,6	1,492	0,414	0,323
PC	12,9	0,483	0,037	0,029
GC	26,5	0,024	0,0009	0,0007

Figure 4.5.16. Estimation of noise cost by zone in Ile-de-France

Source: Created by the author

This method leads to an estimate of the cost of noise in Paris of 41€ per 100km, almost 40 times higher than that of *STIF,* and 3.7€ in the inner suburbs, i.e. 3 times the estimated cost of the STIF. These estimates have their logic, but it is difficult for a PhD student to propose estimates that are so different from the official estimates.

Moreover, it cannot be excluded that density is itself a source of acoustic comfort (buildings on the street acting as a screen for other buildings), and, moreover, that the same sound exposure is experienced differently depending on the context. This is why we take up the slightly more complicated methodology (Orfeuil, 2006). It takes the national population noise exposure data (x1 people exposed to more than 70 dB(A), x2 exposed to 69, etc. up to 55 dB(A), and assigns the people concerned to territories classified by decreasing density. Thus the 2.4 million people exposed to more than 70 dB(A) are assigned to Paris and then to the area of highest density, those exposed to 69 dB(A) to the area of highest density after Paris as long as their population has not been reached, and so on down the scales of exposure and density simultaneously. Each level of exposure is associated with a level of real estate depreciation (% depreciation in relation to the value of the property). The severity of the nuisance on a territory is then measured by the product of the population and the depreciation rate. This method has advantages and disadvantages. By reducing the reasoning to real estate, pedestrians, whose presence is more than proportional to densities, due to greater use of walking by residents and tourists, are ignored. We have tried to avoid the classic phenomenon of overestimation linked to differences in the intrinsic values of real estate, using only depreciation percentages and not absolute values. On the other hand, it may be thought that property depreciation perhaps better captures differential noise tolerance, since no one expects comparable noise levels in Paris and in a village. The results of the calculations then give the following values for the severity index of one kilometre on a territory, see the following table.

	Ile-de-France			**A. +700** (1)			**A. 300_700** (2)			**A. 100-300** (3)		
	Vkm	Den.	DT	Vkm	Den.	DT	Vkm	Den.	DT	Vkm	Den.	DT
Centre	3,6	32,1	115,6	6,2	10,2	63,2	11,3	6,2	70,1	22	3	66
Suburb	12,9	13,7	176,7	14,6	1,8	26,3	15	1	15	10,7	0,7	7,5

Figure 4.5.17. Distribution of traffic and regional severity indexes

Source: J.-P. Orfeuil, 2006

Note: The severity index in Ile-de-France is 1, as are the suburbs of cities with more than 300,000 inhabitants.

$$a * \sum \mathrm{T_i} * G_i = \mathrm{CB_{national}}$$

With:

T_i is the traffic for region i

G_i is the severity index for the region i

a is a noise coefficient

$CB_{national}$ is the cost of national noise (€2.55 billion)

1.45 billion, representing 56% of the cost of national noise. In addition, the values of noise cost per vkm and per pkm by zone are shown in the following table. These are the values that we will use later in the summary of external costs.

	Noise cost (€/vkm)	**Cost of noise** (€/pkm)
Paris	0,151	0,119
PC	0,065	0,051
GC	0,005	0,004
IDF	**0,046**	**0,036**

Figure 4.5.18. Cost of passenger private vehicle noise per pkm per zone in Ile-de-France

Source: Created by the author

It can be observed that the difference in noise cost between Paris and the inner suburbs has become less than the difference in density, i.e. the number of people exposed, which leads us to consider this estimate as very conservative, and probably too conservative. It is these conservative values that we will use, and which will serve as a basis for calculating the noise nuisance from the other modes. For other means of transport, we will use an equivalent value for motorized two-wheelers[20], and the STIF value for suburban rail networks.

For buses, STIF is retaining a total (44 million) equal to 11.6% of the total for cars. We take this proportion and apply it to a total of 1.45 billion for personal vehicles, which brings us to a bus cost of 168 million. By allocating RATP Paris bus traffic to Paris, RATP suburban buses to the inner suburbs and OPTILE buses to the outer suburbs, we obtain 42, 101 and 126 million vkm respectively, with relative gravity of 32.1, 13.7 and 1. 76 million for Paris, 78 million for the inner suburbs and 8 million for the outer suburbs, i.e. 1.8€ per bus km in Paris, 0.77 in the inner suburbs and 0.06 in the outer suburbs. With pkm to bus-km ratios of 19.4, 16.4 and 11.5, respectively, this gives costs per 100 pkm of 9.7, 4.9 and 0.51 in Paris, in the inner and outer suburbs, see the following table. These evaluation results are also significantly higher than those of STIF.

	Traffic (million vkm)	Occupancy rate (passenger/bus)	Noise cost (€/vkm)	Cost of noise (€/pkm)
Paris	42	19,4	1,886	0,097
PC	101	16,4	0,805	0,049
GC	126	11,5	0,059	0,005
IDF	-	-	**0,624**	**0,043**

Figure 4.5.19. Cost of bus noise per pkm per zone in Ile-de-France

Source: Created by the author

[20] The Honda motorcycles facts and figures book shows noise standards for motorized two-wheelers equivalent to those of PV for mopeds and scooters. Only very large motorcycles deviate from these standards. But there is a difference between the standards and practices, with in particular engine unblocking behaviours that are widespread.

Based on the results of the evaluation of noise cost per mode, we can see that motorized vehicle modes have a higher cost per pkm than PT. However, this assessment is not yet sufficient, because the cost of noise also depends on population density. For this reason, we can redistribute this noise cost by area according to a method related to population density and logarithmic traffic density, see the following formula.

$$a * \sum D_i * \log_{10}(DT_i) = T * V$$

With
D_i is the population density for zone i
DT is the traffic density for the zone i
T is the total regional traffic
a is a noise coefficient
V is the regional unit noise cost per vkm

4.5.3. The greenhouse effect

Investment choices for transportation infrastructure need to take into account some long-term effects that, although appreciated with more uncertainty than more immediate effects, are nonetheless real. The traditional decision-support tool of economic calculation uses a discount rate that, by its nature reflecting a social preference for the present, tends to depreciate gains and losses all the more as they are realized in the distant future. This classic approach is problematic when the calculation comes to minimize irreversible effects that are poorly appreciated by economic agents. Two such effects are of particular concern in the transport sector. The first concerns the evolution of oil resources, of which transport is a major consumer; the second is related to the risks to the planet of carbon dioxide emissions into the atmosphere, to which the sector is a major contributor (Boiteux, 2001).

The presence of certain gases[21], the main one being carbon dioxide or CO2, in the earth's atmosphere limits the solar radiation reflected by the earth. Moreover, the GRENIER report (2006) shows that the proportion of greenhouse gases emitted by transport accounted for 26% of total greenhouse gas emissions in France in 2004 (industry reached 20%, construction reached 19%, etc.). In addition, these transport emissions increased by 23% between 1990 and 2004 according to IFEN (2003) sources.

In France, carbon dioxide (CO2) accounts for 71% of the increase in the greenhouse effect, which is measured according to the Global Warming Power-GWP indicator (PREDIT, 1999). Any combustion inevitably produces CO2. Plants use part of the CO2 emitted, but not enough to absorb all the CO2 from fossil fuels (oil, gas and coal). Road traffic was responsible for 24% of CO2 emissions in France in 2004 compared to 2% for other modes of transport. Of this total, 65% came from PV[22].

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[21] The six gases considered in the Kyoto Protocol are: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).

[22] According to the Science-Decision report (2006), 30% was also indicated for heavy trucks, 3% for PT and 2% for two-wheelers.

4.5.3.1. Results of the main studies

Following the description of the main elements related to the greenhouse effect, we can first present the 6 correlative studies on the estimation of the cost of the greenhouse effect. Normally, the estimation of the value of the greenhouse effect seems to be as varied at the regional and national scale. However, we can see that the assessment result of Boiteux and INFRAS/IWW is relatively close. Indeed, the cost of the greenhouse effect is normally the same, since this environmental impact is global. Therefore, the difference between the values assigned in the following table can be explained by the occupancy rate per mode and per zone.

<table>
<tr><th>(€/pkm)</th><th colspan="3">Regional level</th><th colspan="3">National level</th></tr>
<tr><td>Study</td><td>Boiteux</td><td>CERTU</td><td>UITP</td><td>INF./IWW (2)</td><td>IFEN (6)</td><td>IMPACT</td></tr>
<tr><td>Years</td><td>2001</td><td>2000</td><td>1999</td><td>2000</td><td>2007</td><td>2007</td></tr>
<tr><td>Car</td><td>0,018 (1)
0,01</td><td>0,005</td><td>0,01- 0,05</td><td>0,0176</td><td>0,0074</td><td rowspan="3">0,0067 (3)
(0,0019-0,012)
0,0052 (4)
(0,0014-0,0093)</td></tr>
<tr><td>Motorcycle</td><td>0,008
0,007</td><td>0,002</td><td>-</td><td>0,0117</td><td>0,0027</td></tr>
<tr><td>Bus</td><td>0,008</td><td>-</td><td>0,01</td><td>0,0083</td><td>0,0097</td></tr>
<tr><td>Rail</td><td>-</td><td>0,005 (7)</td><td>0,003</td><td>0,0059</td><td>-</td><td>0,00 (5)</td></tr>
</table>

Figure 4.5.20. Regional and national greenhouse gas values

Source: Created by the author

Note: 1. In red colour, it is the value in urban areas, and in blue colour, it is in rural areas.
2. The average cost of air pollution in Europe (17 countries)
3. Unit cost (Interval) of road transport in gasoline in urban areas
4. Unit cost (Interval) of diesel road transport in urban areas
5. Electric train. If the train is diesel, the unit cost is 0.114/vehicle kilometre.
6. Cost of the greenhouse effect in vehicle-kilometres
7. Diesel train

4.5.3.2. Estimated value

Ile-de-France

100 per ton of carbon for the period from 2000 to 2010 or the equivalent of €0,066/l of gasoline and €0,073/l of diesel. This price[23] corresponds to the value of carbon that is obtained under the hypothesis of a progressive use of flexibility mechanisms at the international level to achieve a future concentration target that avoids the main damage (Boiteux, 2001). In essence, the carbon value projected by the government is aimed at achieving the emission reduction target in the Kyoto Protocol.

The Stern Review (2006) reaches similar conclusions. A recent report (Quinet, 2008) proposes, on the basis of the European Union's recent commitments that go well beyond Kyoto, to increase this reference value by 80% by 2020 and by 200% by 2030.

[23] The tons of carbon produced in the transportation sector can be expressed in litres of fuel (indistinctly gasoline or diesel for a first approximation). Using a coefficient of 0.83tC per Toe (ton of oil equivalent) or 0.71kgC per litre of fuel, a tax internalizing the value of €100 per ton of carbon would amount to €0,46 per litre.

For emissions related to passenger transport in Ile-de-France, the overall estimate is €271m in 2003, including €256m for private and commercial cars, €5m for two-wheelers and €10m for PT. Therefore, according to the total cost of the greenhouse effect estimated by STIF, we can evaluate the unit cost of the greenhouse effect per mode in Ile-de-France:

€0,0069/vkm (PV);
€0,0039/vkm (two-wheelers);
€0,0064/vkm (taxis);
€0,0019/pkm (buses).

The cost of the greenhouse effect per mode varies little by zone. For this, we refer to the average values attributed by STIF for the modes. In addition, in both Europe and Japan, we neglect the greenhouse effect costs produced by electric rail.

Cost related to the greenhouse effect	**Car**	**Motorcycle**	**Bus**
Cost/pkm (€/pkm)	0.0054	0.0039	0.0019

Figure 4.5.21. Greenhouse effect cost per pkm in Ile-de-France

Source: STIF, 2005

4.5.4. Congestion

Congestion is the direct consequence of excess demand over road supply. The literature on the costs of congestion is extremely abundant, and generations of economists have studied the marginal costs of congestion.

Congestion has a special place in the socio-economic assessment of transport infrastructure projects, and this in two respects. On the one hand, the study of congestion only makes sense from an economic point of view in an approach that covers both the optimization of investments, infrastructure pricing and the level of service quality offered. On the other hand, congestion must be understood as an external effect of a category of users on itself, and on the other hand, public roads are the site of multiple uses that are not limited to traffic alone. Therefore, the socioeconomic appraisal of a project must clearly distinguish between purely transport-related effects of congestion, such as vehicle time savings or losses, and broader effects on other road functions. In addition, the effects of congestion include longer and more uncertain travel times, oversized fleets of rolling stock and personnel, increased fuel consumption and vehicle maintenance costs, increased pollution, and a deteriorating living environment.

The deterioration of traffic conditions is attributable to PV. It generates a cost for those who cause it, the motorists, but also for the companies operating public transport and the users of public transport. This section is inseparable from the previous section on the value of time, since most of the costs of congestion are measured by valuing the time lost as a result of congestion. It is therefore less a question of costing than of clarifying many of the issues that are problematic when dealing with the economic calculation of congestion.

4.5.4.1. Theory of congestion cost evaluation

In general, the reduction in travel speed due to congestion can be represented by the following equation (combining flow and speed).

$V_q = \bar{v} - bq$ (24)

Where, $\bar{v}$ is the average speed with uncongested (km/h); q is the volume of traffic (vehicle); v_q is the average speed when the volume is q (km/h); b is constant. When a new PV is added to the traffic volume (named $q+1$), it can be written that the annual cost of congestion (G) is represented as the following formula according to the value of overtime for the mode of transport i :

$$G_i = \left\{ \bar{d} * \left(\frac{1}{v_{q+1}} - \frac{1}{v_q} \right) * C_T * n * m \right\} \quad (25)$$

Where, $\overline{d_i}$ is the average distance travelled by vehicle i (km); C_{Ti} is the time value for vehicle i (money/h); n_i is the number of days of use of vehicle i per year; m_i is the total number of vehicle i per day.

Congestion relief gains are very significant and are valued by the time saved by all users in relation to the vehicle * kilometre removed from a congested route.

4.5.4.2. Results of the main studies

As for the studies on congestion cost assessment, we present the five results of congestion assessment at the regional and national levels. Indeed, the congestion cost outcome at the regional level is clearly higher than the national level for both PV and public road transport.

In addition, following the description on the evaluation of the cost of congestion, we can recognize the cost of congestion, which is mainly composed of time lost on the road and the value of time according to the modes[24]. This is the reason why this external cost cannot be cumulated in the total travel cost model in order to avoid double counting, because the potential cost of lost time by modes is already included in the time cost evaluation (average travel time consists of lost time).

[24] The cost of congestion can also include an additional cost to businesses, particularly those operating PT systems. This additional operating cost is already included in the PT operating expenses corresponding to the means that would be saved if the target speed was reached (STIF, 2005).

(€/pkm)	Regional level			National level	
Study	STIF	UITP	ITS (4)	UNITE	VTPI (6)
Years	2003	1999	2001	2002	1996
Car	0.187 (1) 0.160 (2) 0.080 (3)	0.01 - 0.07	0.84–2.93 (5) 0.31–1.48 0.49–0.62	0.39 – 0.11	0.170 (U) (7) 0.00 (R)
Motorcycle (10)	0.062 - 0.053 - 0.00	-		0.34 – 0.11	0.170 (U) 0.00 (R)
Bus	0.094 (8) 0.051 (9)	< 0.001		0.48 – 0.14	0.340 (U) 0.00 (R)
Rail	-	0.00	-	-	-

Figure 4.5.22. Congestion value at regional and national level

Source: Created by the author

Note: 1. Estimated value for the central zone (Paris).
2. The estimated value for the small crown area.
3. The estimated value for the large crown area.
4. Estimated value of congestion in €/vehicle-kilometre in the city of London.
5. The value marked in red colour is the cost in the central area; in black colour is the near suburban area and the value for the rural area is marked in blue colour.
6. Estimated congestion value in the United States in 1996 in $/vehicle mile.
7. U: urban; R: rural.
8. Estimated value for the dense area (Paris and inner suburbs).
9. Estimated value for the suburban area (Greater Montreal suburbs).
10. One third of the value of automobiles for Paris and PC. As for the value for the inner suburbs, it is zero in this zone.

4.5.4.3. Estimated value

In Ile-de-France

Different estimates are available for the cost of congestion in Ile-de-France. STIF proposes an indicative estimate for the time lost by motorists: 1,100 million hours over the year, calculated as the difference between door-to-door times observed in the EGT 2001 and a reference speed of 40km/h. The cost of congestion for bus users is assessed by the difference between reality and a fluid reference situation (16km/h in Paris and 20km/h in the inner suburbs) and estimates the time lost by these users at 33 million hours, from which a congestion cost of €335m is deducted for them, to which €100m is added for bus users in the inner suburbs. A very precise economic estimate of the cost of congestion on the ring road has been made (Prud'homme, 1999). Based on a time value of 12€ per hour, it comes to €100m. Since the ring road accounts for 36% of traffic congestion in Ile-de-France, it infers a value of €255m for Ile-de-France, or 21,3 million hours lost. The difference is very significant, and is partly explained by the fact that implicitly only congestion on the national network (national roads and freeways) is taken into account. Another approach is proposed (Tison, 1997). He constructs a typology of trips based on the types of connection (centre-centre, centre-suburbs, etc.) and their length. Within each type, he evaluates the speeds of door-to-door travel at night, during morning peak, off-peak, and evening peak hours, and takes off-peak hours as the reference situation. For each segment of the typology, it calculates time losses such as those resulting from driving at a lower speed during off-peak hours. It obtains a result in % of additional time per link. In order to have absolute losses, we calculate the time spent per link from the data of the EGT 2001.

	Centre - Centre	Suburban - Suburb	Periphery - periphery	Centre - Periphery	Suburbs - Periphery	Centre - Suburb	Total
Loss of time (%)	8,00	5,50	3,80	6,30	0,09	0,15	-
Distances (millions km/day)	1,80	6,90	7,40	11,70	18,90	33,80	80,50
Speeds (km/h)	7,40	12,80	24,70	11,50	23,20	19,80	18,10
Duration (1000h/day)	243,00	539,00	300,00	1020,00	815,00	1710,00	4627,00
Loss of time (1000h/day)	19,50	29,60	11,40	64,30	73,40	256,50	454,70

Figure 4.5.23. Proportion of reduction in PV travel time between peak and off-peak times in Ile-de-France

Source: Created by the author

This results in a loss of 455,000 hours per day for drivers, or 591,000 hours for the driver and passenger combination, representing 9.84% of the time spent in PV. This represents 9.84% of the time spent in PV. This translates into 136 million lost hours based on working days per week and 46 weeks of non-vacation traffic. By construction, this estimate is higher than Remy Prud'homme's since it includes traffic on all lanes. It is 8 times lower than STIF's, but nevertheless leads to an overall congestion cost of around €1,4b. Using the grids of distances travelled by type of link to traffic on the territories, see the table below, and applying them to lost time, we obtain the following estimates by territory.

	Distance in Paris (%)	Distance in PC (%)	Distance in GC (%)
Paris-Paris	100		
Paris-PC	54,15	45,85	
Paris-GC	15,05	41,98	42,97
PC-PC		100	
PC-GC		35,44	64,56
GC-GC			100

Figure 4.5.24. Proportion of travel distribution by territory in Ile-de-France

Source: Created by the author

	Paris	PC	GC	Total
Distance by PV (driver) 1000 vkm/day	21,86	34,01	24,63	80,5
Distance by PV (passenger + driver) thousands of pkm per day	27,98	43,53	31,53	103,04
Duration (1000h/day)	1320,7	2037,6	1262,7	4621
Loss of time (1000h/day)	168,07	200,22	86,42	454,7
Proportion of time lost (%)	12,73	9,8	6,84	9,84
Lost time per km (h)	0,006	0,005	0,003	0,004
Congestion cost per trip (€/trip-km)	**0,061**	**0,046**	**0,028**	**0,044**

Figure 4.5.25. Time lost per territory and time lost per km on the territory for PV journeys in Ile-de-France

Source: Created by the author

Not only do motorists lose time, but bus users lose time as well. According to STIF, there are 0.8 billion pkm on Paris buses, 1.7 billion on RATP suburban buses, and 1.5 billion on OPILE buses. Assuming respective speeds of 14, 17 and 20km/hr, we would then have 58 million hours spent in Parisian buses, 97 million in RATP suburban buses and 70 in OPTILE buses.

If we assume that users lose time in the same proportions as motorists[25] (12.73% in Paris, 9.83% in PCs and 6.84% in GCs, then the time lost would be 22.23 million hours per year for bus journeys in Ile-de-France), compared with the 33 million hours per year retained by STIF for RATP buses. Therefore, the evaluation result of the total time losses for bus routes in our research is 1.5 times lower than the one attributed by STIF. In this logic, we can evaluate the cost of congestion is €0,084/pkm in Paris, €0,053/pkm at PC and €0,031/pkm at GC. The average congestion cost in Ile-de-France is €0,053/pkm.

	Paris	PC	GC	Total
Total annual traffic (millions pkm)	815,9	1653,4	1408	3877,3
Speed (km/h)	14	17	20	17,2
Duration (millions h/year)	58,28	97,26	70,4	225,9
Proportion of time lost	12,73%	9,83%	6,84%	9,84%
Loss of time (millions h/year)	7,42	9,56	4,82	22,23
Lost time per km (h)	0,009	0,006	0,003	0,0057
Congestion cost per trip (€/trip-km)	0,084	0,053	0,031	0,053

Figure 4.5.26. Time lost per territory and time lost per km on the territory for bus routes in Ile-de-France

Source: Created by the author

4.5.5. Accidents

Accidents resulting from the movement of people, mainly those related to automobile traffic, are also included under negative externalities generated by passenger transportation. It is therefore necessary to assess the financial impact of bodily injury resulting from these accidents. It is necessary to assess all of these costs for a number of reasons, not least to establish the extent of the monetary consequences of accidents and to assess their weight relative to other costs incurred by the company. The aim is to have a value that can be used in the transport sector to assess consistently a variety of investment options with different safety impacts and to ensure that the most efficient use is made of available resources. This is not so much a question of determining the value of human life per se, which is a difficult task, as it is a question of setting a guardian value that the community will implicitly or explicitly accept as a value for a life saved, or a life lost, in the transport sector.

[25] The proportion of time lost per territory is the time lost divided by the total travel time (total distance of PV driver divided by the respective speed) in each territory.

4.5.5.1. Literature review

The literature on the social cost of accidents is extremely abundant, and international comparisons are very frequent. There are two points of view that are particularly noteworthy:
- the reality of the damage is not in doubt here, on the other hand its valuation through the value of human life depends strongly on the value we adopt for it.
- the values adopted by road administrations vary widely from country to country. They are generally lower than those adopted by other transport systems and by industry.

In addition, we can also observe the accident values announced by previous research, see the following table. Indeed, the cost of accidents related to motorcycle use is always the highest in these five studies. Moreover, the value of accidents for the motor vehicle mode is always higher than for the public transport mode.

(€/pkm)	Regional level		National level		
Study	CERTU	UITP	INFRAS/IWW	UNITE (1)	VTPI (2)
Years	2000	1999	2000	1998	1996
Car	0,016	0,005 - 0,025	0,0309	0,021	0,035
Motorcycle	0,079	-	0,1886	0,617	0,077
Bus	0,005	< 0,001	0,0024	0,0006	0,2
Rail	-	< 0,001	0,0007	0,023	-

Figure 4.5.27. Cost of insecurity per pkm at regional and national levels

Source: Created by the author

Note: 1. The value of accidents in Great Britain includes the external value and the risk value.
2. The external value of accidents in the United States in 1996 per $/vehicle mile

4.5.5.2. Estimated value

In Ile-de-France

In 2004, 20,201 road accidents were recorded in Ile-de-France, resulting in 24,757 victims (killed, seriously injured, slightly injured), a 27.4% decrease in the number of accidents and a 32.3% decrease in the number of victims compared to 1995. In addition, the SNCF and RATP railways recorded 24 victims with serious injuries, 21 of whom died in 2003.

	Killed	Seriously injured	Minor injuries	Gross cost of insecurity (millions €)
Pedestrian	77	471	4189	260,6
Cyclists	12	73	971	48,2
Motorcycle	141	788	7836	469,2
Cars	208	574	8591	526,8
Other (trucks, etc)	10	39	777	35,9
Total	**448**	**1945**	**22364**	**1340,7**

Figure 4.5.28. Traffic accidents in Ile-de-France

Source: French road safety agency, 2004; Boiteux, 2004

We use the values recommended by Boiteux to evaluate in euros the numbers of fatalities, serious injuries and minor injuries. The gross safety cost is obtained by applying the standard cost values (€1,1m per fatality, €0,16m per serious injury, €0,024m for minor injuries). In addition, the 2004 annual report of the regional road safety observatory gives the number of accidents by type of user in Ile-de-France.

External cost (€/pkm)	Zone	Motorcycle	Car	Bus	Rail
Pollution	Paris	0,111	0,111	0,067	0
	PC	0,046	0,046	0,028	0
	GC	0,007	0,007	0,002	0
	Average	0,029	0,029	0,027	0
Greenhouse effect	Paris PC GC	0,004	0,005	0,002	0
Noise	Paris	0,119	0,119	0,097	0,004
	PC	0,051	0,051	0,049	0,004
	GC	0,004	0,004	0,005	0,004
	Average	0,036	0,036	0,043	0,004
Accident	Paris	0,32	0	0,004	0,003
	PC	0,152	0	0,004	0,003
	GC	0,295	0	0,004	0,003
	Average	0,239	0	0,004	0,003
Total	Paris	0,554	0,235	0,17	0,007
	PC	0,253	0,102	0,083	0,007
	GC	0,31	0,016	0,013	0,007
Average		**0,308**	**0,07**	**0,076**	**0,007**

Figure 4.5.29. Traffic accidents by mode in Ile-de-France

Source: IDF Road Safety, 2004

According to the above figure on accidents by type of user, we first ignore the HGV and LCV costs. In addition, we allocate the "pedestrian and cyclist" safety costs to the modes in proportion to their regional traffic (19% LCV and HGV, 78% car, 2% motorized two-wheelers). Then, we again ignore the pedestrian and cyclist costs for LCVs and heavy goods vehicles. The rest gives the overall accident costs for LCV and 2WD in the region (€1246m, of which €479m for motorcycles and the rest €768m for cars).

After having evaluated the gross cost of insecurity related to the use of PV and motorcycles, we can deduct from this gross cost of insecurity for PV and motorized 2-wheelers half of the insurance costs for PV and motorized 2-wheelers (the other half concerns material damage). According to STIF (2005), insurance costs related to the use of PV amounted to €3050m in 2003 (€620 per vehicle per year) and insurance costs related to the use of motorized 2-wheelers amounted to €180m in 2003 (€450 per motorcycle per year). In addition, we have to consider the coefficient 0,7 for passenger PV traffic in Ile-de-France and at the same time deduct the tax rate in the insurance expense.

In accordance with the estimate of the gross cost of insecurity related to the use of PV and motorized two-wheelers and the insurance expenditure for PV and motorcycle, we can first observe that the net cost of insecurity for PV is zero[26], since the insurance expenditure can cover all the costs of insecurity. As for the net cost of insecurity related to the use of motorized two-wheelers, it is €389m (€479m minus €90m) of which there are €95m of the net insecurity cost for the Paris area, €106m for PCs and €187m for GCs. Compared to motorcycle traffic by zone (297m vkm in Paris, 698m vkm in PC and 636m vkm in GC), the net insecurity cost for motorcycle traffic by zone is €0,32/vkm in Paris, €0,152/vkm in PC and €0,295/vkm in GC). As for the unit cost of accidents in PT, the cost of accidents is €81m in 2003 according to the STIF database. For this, we can estimate that the cost of accidents in PT is €0,0035/pkm compared to the total traffic in PT 24,3b pkm.

4.5.6. Findings

First, we can combine your estimated external cost data for Ile-de-France. For the non-motorized modes (walking and cycling), we assume here that the external cost is zero because it is very minor compared to the other modes.

According to the tables below, we can observe that the external cost of the motor vehicle is normally higher than public transport and the external cost in urban areas is higher than in the suburban area. In addition, the distance travelled by motorized vehicle in the suburban area is always longer than in the central area. Therefore, the efficient development of public transport, especially the rail network, is theoretically the best way to reduce environmental impact, although there are other problems, notably the question of financing.

In addition, the cost of congestion is the most important cost compared to other external costs in Ile-de-France[27]. That is, reducing the cost of congestion is a more important in order to lower the total social cost, especially the cost of congestion caused by PV. However, this external cost cannot be shown in the external cost tables because it is already taken into account in the cost of time part. Moreover, the importance of external costs is always different, except for the cost of congestion. Moreover, we will retain these evaluation results in the following synthesis of the total cost of travel.

[26] Half of the insurance expenditure excluding VAT (3050/1.3*0.5) multiplied by the coefficient (0.7) of regional traffic is €821m. This value can cover all the costs of car accidents (€767m).

[27] In Ile-de-France, the congestion cost for the car is €0,061/pkm in Paris; €0,046/pkm in PC and €0,028/pkm in GC (the average is €0,044/pkm), for the bus is €0,084/pkm in Paris; €0,053/pkm in PC and €0,031/pkm in GC (average €0,053/pkm).

External cost (€/pkm)	Zone	Motorcycle	Car	Bus	Rail
Pollution	Paris	0,111	0,111	0,067	0
	PC	0,046	0,046	0,028	0
	GC	0,007	0,007	0,002	0
	Average	0,029	0,029	0,027	0
Greenhouse effect	Paris PC GC	0,004	0,005	0,002	0
Noise	Paris	0,119	0,119	0,097	0,004
	PC	0,051	0,051	0,049	0,004
	GC	0,004	0,004	0,005	0,004
	Average	0,036	0,036	0,043	0,004
Accident	Paris	0,32	0	0,004	0,003
	PC	0,152	0	0,004	0,003
	GC	0,295	0	0,004	0,003
	Average	0,239	0	0,004	0,003
Total	Paris	0,554	0,235	0,17	0,007
	PC	0,253	0,102	0,083	0,007
	GC	0,31	0,016	0,013	0,007
Average		**0,308**	**0,07**	**0,076**	**0,007**

Figure 4.5.30. External cost per pkm by zone and by mode in Ile-de-France

Source: Created by the author

Note: It can be seen that the evaluation of the external cost does not take congestion into account.

4.6. Overview of travel costs

Following the description on the evaluation of modal-related travel costs in the city, we have observed that these evaluation results can give us interesting indications to explain the current phenomena of urban mobility in urban areas on the one hand and on the other hand to chart the way for a more sustainable development of urban transport.

To do this, we aim to summarize the costs of travel by mode related to private spending (users or employers), public spending and also external costs. On the basis of these results of the evaluation of travel costs, we can compare the strengths and weaknesses between the different modes, and at the same time establish the government's summation in terms of public revenue and public expenditure.

Based on this assessment of the costs of travel, we have also defined the two approaches to valuation: the accounting approach (recurrent approach) to reflect current transport cash flows and the economic approach (development approach) to consider the potential costs of transport development. The accounting approach is most appropriate when traffic is no longer increasing in the city. The economic approach is more appropriate when urban transport is being developed, because it is able to assess the cost of transport development in terms of depreciation of equipment and land prices.

After assessing the costs of travel in the megacity, the purpose of this section is twofold: first, to indicate the cost estimation results associated with the two evaluation approaches, and second, to clarify the relationship between the development of PV and PT transport and the evaluation results.

In addition, by explaining the approaches to the evaluation of travel costs in the city, we aim to present the four main points related to the two approaches in the Ile-de-France case study: cash flows and aggregate cash flows (see section 4.6.1), the economic approach (see section 4.6.2) and the disaggregated accounting approach (see section 4.6.3).

4.6.1. Summary of travel costs

After having evaluated travel costs in the second part, we gather the results of the evaluation of these travel costs relative to individual, government and external costs related to vkm and pkm for the use of motorized vehicles (motorcycle and car) and public transport (bus and rail) in the following tables for Ile-de-France and Yokohama.

In both areas, the summary of travel costs is represented by the valuation result related to the cash flows from the use of PV and PT for individuals and communities, because the accounting approach (recurrent approach) can reflect current expenditure by activity and by mode.

Next, we aim to compare the private cost (user cost and cost of time) of travel in PV, motorcycles and public transport linked to the aspect of individuals, the summation of public authorities for travel in PV, motorcycles and public transport linked to the aspect of public authorities and the external cost for these three modes linked to the aspect of the environment for society.

4.6.1.1. Private vehicle travel costs

In Ile-de-France

Car travel costs	Total cost Billion of €	Cost/vkm €/vkm (3)	Cost/trip-km €/pkm
Private spending by users			
1. Fixed cost	18,705	0,435	0,34
2. Variable cost	7,32	0,17	0,133
3. Set (3)=(1+2)	26,025	0,605	0,473
4. of which excluding specific taxation (4)=(3-5)	21,589	0,503	0,393
5. of which specific taxation (1)	4,436	0,102	0,08
Private spending by employers			
6. Parking cost	1,9	0,044	0,034
Travel time expenditure			
7. Cost of time	30,27	0,704	0,55
Government spending on roads			
8. How it works	0,862	0,02	0,016
9. Investment	0,596	0,014	0,011
10. Set (10)= (8+9)	1,458	0,034	0,027
External costs (4 types) (2)			
11. Total	3,853	0,09	0,07
12. Carrying cost (12)=(4+6+7+10)	48,6	1,131	1,004
13. Accounting and external costs (13)=(12+11)	52,45	1,221	1,074

Figure 4.6.1. Costs of private vehicle travel using the accounting approach in Ile-de-France

Source: Created by the author

Note: 1. Including on-street parking fees.
2. The external cost includes the cost of pollution, noise, the greenhouse effect and accidents.
3. PV occupancy rate is 1.28 in Ile-de-France.

Following the results of the evaluation of PV travel costs above, we aim to estimate the government's accounting summation related to road expenditures and PV revenues. The government summation is the government revenue related to specific taxes (5) minus the government expenditure related to operations and investment (10). For this, the accounting cost of public authorities for roads in Ile-de-France is +0.053 €/pkm, which means that public revenue covers all public expenditure for the use of roads in Ile-de-France.

But this government summation is not sufficient in the context of society, so we have to add the external cost to the government summation. That is to say, the overall summation, including the external cost, is counted by revenues (5) minus expenditures (10) and minus external costs (11). Thus, the overall public provision accounting summation for roads is -0.017 €/pkm, which means that public revenues were not sufficient to cover all public expenditure and external costs for PV use in Ile-de-France.

4.6.1.2. Motorcycle travel costs

Apart from PV use in urban areas, motorcycle mode also plays an important role, although the rate of motorcycle use is not significant now in Ile-de-France. After having evaluated the costs of motorcycle travel, we can observe that this mode is obviously more economical and practical than PV for trips in the city according to the private cost related to users' private expenses and travel time.

In Ile-de-France

The government summation for motorcycle-related roads is +0*.018* €/pkm (government expenditure minus specific tax revenues) and the overall government summation (adding the external cost in the summation) is -0*.29* €/pkm. This means that the costs related to road spending and external costs for motorcycles are not balanced by the public revenues related to motorcycle use in Ile-de-France, due to the very high costs of insecurity. It is difficult to distinguish between the costs attributable to motorcyclists and those related to PV traffic.

Car travel costs	Total cost Thousand of €	Cost/trip-km €/pkm
Private spending by users		
1. Fixed cost	314,6	0,193
2. Variable cost	163	0,1
3. Set (3) = (1+2)	477,6	0,293
4. of which excluding specific taxation (4) = (3-5)	427,1	0,262
5. of which specific taxation	50,5	0,031
Travel time expenditure		
6. Cost of time (1)	652.0	0,4
Government spending on roads		
7. Total	21,2	0,013
External costs (4 types)		
8. Total	502	0,308
9. Book Cost (9) = (4+6+7)	1100,3	**0,675**
10. Accounting and external costs (10) = (9+8)	1602,3	**0,983**

Figure 4.6.2. Motorcycle travel costs in Ile-de-France

Source: Created by the author

Note: 1. The value of the time for motorcycle is 10 €/hour, like the value for PV.

4.6.1.3. Mass transit travel costs

In Ile-de-France

PT in Ile-de-France is made up of buses, subway and RER. We list the respective travel costs by mode and the average cost of travel in public[28] transport in the following table.

First, the government summation for PT (revenues minus operating and capital expenditures) is equal to the net public cost (6) in the following figure 4.6.3. The estimation result may give us that government revenues related to user fare revenues and employer-charged transport payments cannot sufficiently cover all government expenditure for PT because the government economic summation is -€0.050/pkm.

In addition, the overall summation (including external costs) is -€0.069/pkm. Even when considering the transport payment as a private expense, the summation for public authorities of PT is worse than that of the car, although the external costs are lower.

Car travel costs		Bus €/pkm	Subway €/pkm	RER €/pkm	Average €/pkm
Private spending by users					
1.	Variable cost	0,22	0,11	0,09	0,12
Private spending by employers (1)					
2.	Total	0,119	0,119	0,119	0,119
3.	of which transport-related payment	0,094	0,094	0,094	0,094
4.	of which related to the orange card	0,025	0,025	0,025	0,025
Travel time expenditure					
5.	Cost of time	1	0,82	0,6	0,70 (2)
Government spending on public transportation					
6.	Net public cost	0,156	0,061	0,016	0,05
External costs (4 types)					
7.	Total	0,076	0,007	0,007	0,02
8.	Book cost (8) = (1+2+5+6)	1,495	1,11	0,875	**0,989**
9.	Accounting and external costs (9) = (8+7)	1,571	1,117	0,882	**1,009**

Figure 4.6.3. Public transportation travel costs in Ile-de-France

Source: Created by the author

Note: 1. Linked to the transport payment in Ile-de-France
2. The average time cost for PT refers to the *EGT* data whose time value is assumed to be the same as PV (10 €/h).
3. The employers' contribution can be divided into two parts: one is €0,6b related to subscription reimbursements and the other is €2,3b related to transport payments.

[28] The average PT travel cost can be estimated by the travel cost per mode and the total traffic per mode. In Ile-de-France, there were 24.3 billion pkm in 2003, of which 6.0 billion pkm were in the subway, 14.1 billion pkm on the RER and 3.9 billion pkm on buses.

4.6.1.4. Comparison between modes

After showing the synthesis of the costs of PV and PT travel, we aim to compare succinctly the important figures related to private cost (the aspect of individuals), the summation of public authorities (the aspect of communities) and external cost (the aspect of society), see the two following tables. The government summation symbolizes the public cost borne by communities, because it is evaluated by public revenue minus public expenditure.

In Ile-de-France

First of all, in Ile-de-France, we can see that the motorcycle is obviously more economical than PV and PT according to the private cost related to the private expenses of users and employers and the expenditure of time. Moreover, the private cost of PT is relatively more economical than that of cars. This means that the development of motorcycles has certain advantages from an economic point of view for users, particularly in terms of the private cost of travel time.

As far as the public authorities' summation for the use of modes is concerned, motor vehicle modes are positive, which means that public revenue is higher than public expenditure, whereas the PT mode is negative in Ile-de-France. This result can give us a consistent sign that there is little expenditure now related to roads in Ile-de-France, because traffic is no longer increasing. On the contrary, if there are new road projects in the future, the economic summation of public authorities may be changed for PV. Moreover, it is also a sign of under-pricing of public transport.

Moreover, if we consider the external cost in the private cost and the public authorities' summation, the motorcycle is more competitive compared to PV and PT according to the global accounting cost (4). Moreover, the overall public accounting summation (5) for the motorcycle is more negative than that for PV and PT because of the higher external cost. This shows the interest in developing efforts to make this mode safer, given that the cost of motorcycle insecurity is very high.

Moreover, the overall government summation is always negative for all three modes, meaning that government revenues are not sufficient to cover public expenditure and external costs.

	€/pkm	Car	PT	Motorcycle
1.	Private cost (private expenses + cost of time) (1)	1,057	0,939	0,693
2.	Summation for public authorities	+ 0,053 (2)	- 0,050 (3)	+ 0,018 (4)
3.	External cost	0,07	0,02	0,308
4.	Total accounting cost (4) = (1)-(2) + (3)	1,074	1,009	0,983
5.	Summation for public authority - External cost (5) = (2)-(3)	-0,017	-0,07	-0,29

Figure 4.6.4. Comparison of travel costs between private vehicle, motorcycles and light rail in Ile-de-France

Source: Created by the author

4.6.2. Economic approach

Following the synthesis of travel costs by mode related to the accounting approach in Ile-de-France, we estimate the summations of travel costs by an economic approach in both Ile-de-France and Yokohama in order to compare the difference between the two approaches. According to the definition of the approaches to evaluating travel costs, the accounting approach linked to current cash flows shows the recurrent cost of travel, while the economic approach linked to the depreciation of equipment and the price of land may instead reflect the cost of development (useful for cities where traffic development remains significant). Therefore, we also aim to present the result of the evaluation of the costs related to the economic approach for Ile-de-France in order, on the one hand, to note the difference between these two approaches and, on the other hand, to observe the potential cost of urban transport development in Ile-de-France, if there are any transport projects coming.

Indeed, the evaluation of travel costs by cash flows is not an economic evaluation, because these cash flows do not incorporate history. An approach in terms of development costs must be based on the present value of the amortization of the investments to be made.

The economic approach only changes the investment cost compared to the accounting approach, because the investment cost is evaluated by the price of the land and the depreciation of the equipment, see the following table. For this reason, we can see that the results of evaluating the total cost of travel related to the two different approaches are not very different. Indeed, the user cost, the cost of time and the external cost are always similar for both the accounting and the economic approaches. As for the operating and capital costs, we take up these evaluation results related to the two approaches in section 4.4. The cost related to capital expenditure estimated by the accounting approach is about 3-9 times lower than that estimated by the economic approach, but this significant difference has little effect on the overall result.

€/pkm	Accounting approach			Economic approach		
	Car	Moto.	Public tranport	Car	Moto.	Public tranport
Private cost (1)	0,427	0,262	-	0,427	0,262	-
Cost of time	0,55	0,4	0,7	0,55	0,4	0,7
Cost of operations + investments (2)	0,027	0,013	0,289	0,106	0,04	0,425
External cost	0,07	0,308	0,02	0,07	0,308	0,02
Total	**1,07**	**0,983**	**1,009**	**1,16**	**1,01**	**1,14**

Figure 4.6.5. Comparison of travel costs related to the accounting and economic approach by mode in Ile-de-France

Source: Created by the author

Note: 1. The private cost for PV travel, which is the private cost excluding specific taxes, includes the private expenses of employers. As for the private cost for PT travel, it is counted in the operating and investment cost for PV.
2. Operating and capital costs of roads and PV.

In addition, the user cost (including the private cost of employers) and the cost of time occupy the largest share of the total cost of travel, for example, they occupy 90% of the total cost of PV travel related to the accounting approach and 85% of the total cost of travel related to the economic approach. That is to say, although the result of the operating and investment cost is very different after the accounting approach, the cost of time and travel is very different after the accounting and economic approaches, the total cost of travel does not change much. This means that most travel costs are still borne by users (user cost and time) in Ile-de-France.

Following the results of the evaluation of the travel costs per pkm in PV, motorcycles and public transport related to the economic approach, we see that the total travel cost per pkm in motorcycles is also more economical than in PV and public transport (1.0 €/pkm for motorcycles against 1.14 €/pkm for public transport and 1.16 €/pkm for PV). Indeed, the travel time factor in PT seems to be relatively more sensitive than in PV, because the cost of time for PT is higher than the social cost. This means that PT really has the relative advantage over motorised vehicles (car and motorcycle) in Ile-de-France according to the social cost of travel (the total cost of travel excluding the cost of time). That is to say, this result of travel cost evaluation can give us a global vision of development which aims primarily at reducing the travel time in PT.

According to the results of the evaluation of the total cost of travel in PV, motorcycles and PT related to the account and economic approach, see the following table, we can observe the two phenomena: Both the economic and the account approach, the PT mode is more economical than the passenger PV mode according to the total cost of travel, and, the motorcycle mode is always more attractive than the other modes. On the other hand, if the cost of time is not taken into account, PT is more economical than motorcycle and PV.

In this logic, we see that reducing the expenditure of travel time is a practicable way for urban transport policies to reduce the total cost of travel, since the user cost, public cost, and external cost will not become increasingly economical by tomorrow.

€/pkm	**Accounting approach**	**Economic approach**
Car	1.07	1.16
Motorcycle	0.98	1.01
Public transportation	1.00	1.14

Figure 4.6.6. Comparison of the total cost in automobile and public transportation related to the different approaches

Source: Created by the author

4.6.3. Disaggregated accounting approach

Based on the results of the travel costs estimated by the accounting approach, we first observed that the use of PV is only slightly more expensive than the use of PT in Ile-de-France. However, this does not mean that the two modes would be equally competitive for all trips in Ile-de-France. This is why we aim to estimate the total cost of travel related to geographical areas in order to distinguish in detail the advantage and disadvantage of PV and PT.

To do so, we use the estimated travel costs for PV, motorcycles and light vehicles after the calculations of our research on travel costs, the distribution of traffic in PV, motorcycles and light vehicles and the EGT data related to the average speed of PV and light vehicles in order to calculate respectively the travel costs for PV, motorcycles and light vehicles related to the geographical areas in Ile-de-France.

(%)	Paris-Paris	Paris-PC	Paris-GC	PC-PC	PC-GC	GC-GC	Total
Automobile	1,90	8,30	8,50	14,80	26,00	40,50	100
Motorcycle	5,70	1,81	18,00	18,00	25,40	14,70	100
Public transportation	6,50	2,14	39,80	8,80	17,40	6,10	100
Billion pkm	**Paris-Paris**	**Paris-PC**	**Paris-GC**	**PC-PC**	**PC-GC**	**GC-GC**	**Total**
Automobile	1,05	4,57	4,68	8,15	14,31	22,29	55,04
Motorcycle	0,09	0,30	0,29	0,29	0,41	0,24	1,63
Public transportation	1,58	5,20	9,67	2,14	4,23	1,48	24,30

Figure 4.6.7. Distribution of traffic in automobile and public transportation in Ile-de-France

Source: EGT, 2011

€/pkm	Paris-Paris	Paris-PC	Paris-GC	PC-PC	PC-GC	GC-GC	Total
Automobile							
Social cost (1)	0,7	0,64	0,55	0,57	0,51	0,48	**0,52**
Cost of time (2)	1,36	0,78	0,4	0,79	0,44	0,48	**0,55**
Total cost	2,06	1,42	0,95	1,36	0,94	0,96	**1,07**
Motorcycle							
Social cost	0,82	0,68	0,54	0,52	0,5	0,48	**0,58**
Cost of time	0,97	0,48	0,28	0,5	0,33	0,53	**0,4**
Total cost	1,79	1,16	0,82	1,02	0,83	1,01	**0,98**
Public transportation							
Social cost	0,32	0,31	0,3	0,5	0,3	0,51	**0,31**
Cost of time	1,51	0,89	0,46	0,93	0,55	0,72	**0,7**
Total cost	1,83	1,2	0,76	1,43	0,85	1,22	**1,01**

Figure 4.6.8. Travel costs related to the accounting approach and the geographical area in automobile, motorcycles and public transportation in Ile-de-France

Source: Created by the author

Note: 1. Social cost consists of the user cost related to private expenditure excluding specific taxation, the public cost and the external cost.

2. The value of time for car, motorcycle and PT is 10€/hour. Here, we do not differentiate the value of time by mode in the cost evaluation approach related to the development aspect.

In accordance with the results of the evaluation of travel costs in PV, motorcycles and public transport related to geographical areas, we can respectively compare the competitiveness of travel costs in PV, motorcycles and public transport in each travel link. First of all, we can see that the total cost of motorcycle travel is normally cheaper than PT and PT in Ile-de-France, except for Paris-GC (higher than PT) and GC-GC (higher than PT).

In addition, the social cost of motorcycle travel is relatively higher than that of public transport and also higher than that of PV on some routes, because the external cost of motorcycles is higher than that of other modes, particularly for the cost of insecurity in Ile-de-France. We then compare the competitiveness between PV and public transport.

Firstly, for radial trips between Paris-Paris, Paris-PC and Paris-GC, public transport is much more competitive than the car, both in terms of the total cost of travel and the social cost of travel, particularly for the central zone (the social cost of travel in public transport is only half that of a car).
Second, for intra-zone PC-PC trips, PT is less attractive than PV in terms of the total cost of travel, but close. On the other hand, the cost of unit time for public transport trips is higher than for trips by PV. In other words, reducing the cost of time for PT in PC-PC trips is capable of increasing the competitiveness of PT.

Thirdly, for intra-zone GC-GC travel, the PT mode is obviously more expensive and less attractive than PV mode because of the high time cost for PT. On the other hand, they have almost the same social cost for travel by PV and PT.

Fourth, for PC-GC inter-zone travel, PT is still higher than PV based on total travel costs.

Comparing the costs of travel in PT and PT with respect to geographical conditions, we can see that the speed of PT is relatively lower for intra-zone travel in suburban areas, because the cost of time for PT use is relatively higher than that for PT use. For this reason, there are three reasons related to the time problem for PT:
- the PT network for suburban ring roads is relatively weak;
- time outside the vehicle for PT is still high (related to the high cost of time), especially in the suburbs, because of the low frequency;
- only one bus mode is used for bypass PT trips.

These observation points can guide us to improve the quality of PT service and at the same time increase its relative advantage over PV.

These comparisons between PV and PT in terms of geographical areas and travel costs in the city can clarify the points of advantage and disadvantage for PV and PT in the city. Moreover, this result of assessing travel costs for different routes is as consistent as the result from local survey data. PT use tends to concentrate intra-zone trips in Paris or radial trips between Paris and the suburbs. As for passenger PV use, it is more likely to be used outside the central city.

This perspective on travel costs is the individual and community aspect. Therefore, if one can divide the total cost into the individual (private cost of use and time) and community (public subsidy to PT and roads) aspects of PT and PT travel related to geographical areas, one can well indicate the more detailed points on the advantage and disadvantage of urban transport development related to PT/PV, the individual/community aspects, and the different areas.

In addition, motorcycle mode seems to be more competitive than passenger PV and light commercial vehicles in Ile-de-France in terms of social and time costs. However, the external cost of motorcycle travel must also be taken into account before developing motorcycling in the city. Indeed, the cost of accidents for motorcycle travel is relatively more expensive (around 25% of the total cost of motorcycle travel). This is the reason why the social cost of motorcycle travel is relatively much higher than that of public transport for travel between Paris and the suburbs.

Overall, these results of assessing travel costs related to the geographical area are useful and practical before implementing the development of PV and PT in the city.

4.6.4. Findings

Having assessed the travel costs associated with accounting and economic approaches in Ile-de-France, we can broadly observe and define the relationship between urban transport development and overall cost evaluation approaches. In fact, the global tools for the evaluation of travel costs are succinctly divided into two: the accounting approach related to current cash flows and the economic approach related to the value of depreciation and land.

To this end, we aim to make important points in order to explain this link between evaluation approaches and the development of PV and PT following the results of travel cost evaluation.

When tracing current cash flows (the accounting approach), we see that the use of PT is more economical than the use of PV, if we consider only the cost related to private and government spending. Then, if we consider the cost of travel time, the cost of travel in PT is close to that in PV (this means that the PT mode does not have the relative advantage of time over PV mode). Then, if we add the external cost to the cost of travel related to cash flow, the use of PT becomes slightly less economical than the use of PT. The accounting approach is adapted to reflect the current situation of the costs of travel in PV and PT in Ile-de-France, because the growth of traffic in Ile-de-France is relatively stable. When we trace the economic approach, we can see that the social cost of travel[29] (excluding the cost of time) in PV is even higher than in PT. Moreover, if we also include the cost of time in the total cost of travel, we can see that the total cost of using PV is also higher than that of using public transport, but not by much. This cost evaluation result is rather related to the future situation for Ile-de-France, if we had the new road and public transport projects.

The total cost of travel related to the economic approach is always higher than that related to the accounting approach, but not very different, because the total cost of travel excluding capital cost, which accounts for about 80% of the total cost of travel, is similar for these two valuation approaches.

When we consider the travel costs related to the disaggregated accounting approach and geographical areas, this gives us a new, more detailed and consistent view to explain the respective competitiveness between PV and TC. Moreover, if only the social cost is taken into account, the public transport mode is always more economical than the passenger PV mode for both inter-zone and intra-zone trips. On the other hand, if we add the cost of time to the total cost of travel, intra-zone travel in the suburbs by PT becomes less and less economical compared to travel by VP, especially in the GC zone.

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[29] Including private, public and external costs.

Based on total cost comparisons related to the accounting and economic approach, we can see that the continued development of public transport in the general sense is useful for individuals and society. Indeed, the total cost of traveling by passenger PV is expected to increase in the future due to fuel scarcity (related to user cost) and environmental impact (related to external cost). For this reason, the reinforcement of the PT network is undoubtedly on the right path in Ile-de-France towards sustainable development. In addition, the disaggregated economic approach can give us a diagnostic tool to indicate the consistency of urban transportation development.

When transport projections are considered in a disaggregated way (using the disaggregated economic approach), then the levers of parking, PT fares, etc. can be put into urban transport development. For example, reducing time and fares for PT use (such as carrot measures), increasing the cost of use through parking charges, pollution charges for PV use (such as stick measures), and so on.

In addition, the urban transportation development perspective focuses not only on the more economical private cost of travel (sustainable mobility), but also on the more economical government summation (sustainable financing) and the more economical external cost (sustainable environment).

4.7. General comparison of travel costs

To facilitate the comparative analysis of costs, we reduce the costs observed to a common unit: the average hourly wage. After having assessed the travel costs related to user and government expenditure in the last section, we have respectively observed the specific characteristics through the private, public and external costs related to travel and modes. In this section, we report some of the costs of travel by PV, motorcycles and public transport at the average hourly wage in order to draw a comparative view of costs.

4.7.1. Comparison of private monetary cost and average wage

The use of modes depends firstly on the ability of individuals to equip themselves with vehicles, and secondly on the cost of using these vehicles and the cost of using public transport. With this in mind, we present in priority two points: one is the annual cost of ownership expressed in hours of work and the other is the variable cost of use expressed in the same unit.

The working time required to own a vehicle

The high rate of PV ownership in Ile-de-France is obviously related to a high wage level and probably to a less unequal distribution of wages. As we know that owning a vehicle has a strong influence on modal choice (it opens up the universe of possibilities, allows people to travel more quickly, but also leads to the formation of habits that reduce the logical nature of choices), we may wonder whether or not it is worthwhile to penalize ownership. Indeed, detention is the source of significant public costs, particularly in terms of space consumption in the central zone.

		Ile-de-France
Hourly wage (€/h)		12,7
Fixed cost		
Motorcycle	Fixed cost (€/year)	801,1
	Fixed cost/wage	**63,07**
Automobile	Fixed cost	5400,5
	Fixed cost/wage	**425,24**

Figure 4.7.1. Comparison of fixed monetary costs versus wages per hour in Ile-de-France

Source: Created by the author

Note: We use here the value proposed by STIF, which is very high.

The working time needed to use the means of transport

The motorcycle is the most economical mode, with a cost of use per kilometre around 1% of the average hourly wage. The difference between the cost of using a PV and a motorcycle is the least pronounced in Ile-de-France, being more pronounced in Yokohama, due to high parking fees.

In Ile-de-France, buses are more than twice as expensive per km as motorcycles, while the difference is much less pronounced in other cities, due to the differentiated pricing of subways and buses. Ile-de-France differs from the other two metropolises in that the cost per kilometre of a bus is significantly higher than that of a train.

In both Yokohama and Ile-de-France, the cost of using buses (per km) is higher than that of the subway. It is related to their respective fare structure: in Paris, fares are identical but bus users generally make shorter trips than subway users. In Yokohama, fare increases proportionally faster to the distance in bus than in subway.

It should be recalled here that in London, bus fares are lower than subway fares. The Parisian option can be defended on an accounting basis: the bus km is more expensive to produce. It can hardly be justified on an economic basis. In fact, the quality of service of the bus (particularly in terms of speed) is lower than that of the subway, which leads to a preference for the use of the subway (leading to its saturation) over that of the bus. In areas where only buses are available (especially in the suburbs on ring roads), the service is far from being equivalent to that of the subway, so that these users, who are often less well-off than those in the central area, actually pay more for the service provided. In addition, it can be observed that the average cost of using a bus is higher than the marginal cost of using a car, which can only increase the difficulties of attracting motorists, who are already deterred by the higher weather. Finally, with a view to greater use of public transport, buses are the mode that has the capacity for the fastest development. Finally, of all public transport modes, the RER has the lowest cost per passenger kilometre. Again, this is quite normal in accounting terms, since the system has high productivity, but it is nevertheless a problem in economic and political terms, since it contributes to the spread of Ile-de-France.

Hourly wage (€/h)	12,7	
Usage cost	Usage cost/pkm (€/pkm)	**Usage cost/pkm/wage** (%)
Motorcycle	0,1	**0,79**
Automobile	0,133	**1,11**
Taxi	1,42	**11,18**
Bus	0,22	**1,73**
Subway	0,11	**0,87**
RER	0,09	**0,71**

Figure 4.7.2. Comparison of monetary user costs versus average wages per hour in Ile-de-France

Source: Created by the author

The working time needed to pay the total cost (fixed + variable) of 1km in the means of transport.

Hourly wage (€/h)	12,7	
Usage cost + Fixed cost	Usage cost/pkm (€/pkm)	**Usage cost/pkm/wage (%)**
Motorcycle	0,293	**2,30**
Automobile	0,473	**3,73**
Bus	0,22	**1,73**
Subway	0,114	**0,9**
RER	0,09	**0,71**

Figure 4.7.3. Comparison of private monetary cost (usage + fixed) versus average wage per hour in Ile-de-France

Source: Created by the author

In terms of total monetary cost, PT is becoming more attractive compared to PV, because it does not have the fixed cost of vehicle ownership. However, motorized vehicles can provide door-to-door service to riders, so the modal split of PT is not ahead of motorized vehicles.

The monetary expenditure on travel time for users must therefore be taken into account, since the cost of time is always higher than other travel costs, both for PV and for public transport.

4.7.2. Comparison of total travel costs to average wages

Here we calculate the total cost, including monetary and time, public and external costs.

In Ile-de-France, the hierarchy is less coherent. Overall, cost differences are smaller, and buses are significantly more expensive than cars, which may explain their low use and the increase in short PV trips. It is also more expensive than the RER. This is not a very favourable situation for the desired development of the compact city.

The overall good performance of public transport should be relative by type of link:

PT is not capable of being the best choice for all trips in the city. On the costs of intra-zone and interzone travel by PV and PT in Ile-de-France, we have clearly observed that PT is obviously less attractive for ring road travel (PC-PC and GC-GC) in Ile-de-France.

Hourly wage (€/h)	12,7	
Total travel cost per pkm	Total cost/pkm (€/pkm)	Total cost/pkm/wage (%)
Motorcycle	0,88	6,69
Automobile	1,07	8,43
Bus	1,57	12,3
Subway	1,11	8,81
RER	0,88	-
Total private vehicle	**1,06**	**8,34**
Total public transportation	**0,92**	**7,24**

Figure 4.7.4. Comparison of total travel costs and average wages per hour in Ile-de-France

Source: Created by the author

Note: 1. Total cost includes private cost (fixed and usage), time cost, public cost and external cost.
2. VP consists of motorcycle and car

Overall government summation and average wage per hour

The government summation is made up of public expenditure (excluding transport payments) and external costs, from which the proceeds of specific taxes are deducted.

This assessment shows strong differences between Yokohama and Ile-de-France:
- motorcycles are relatively expensive in Ile-de-France, mainly because of the cost of insecurity. However, it should be remembered that the cost of insecurity is borne primarily by users, so the public nature of this cost is largely linked to social security coverage;
- PV is always cheaper for the government than public transport, because of the taxes it incurs;
- transport payments are not included in public spending.

Hourly wage (€/h)	12,7	
Overall public authorities performance	Performance/pkm (€/pkm)	Performance/pkm/wage (%)
Motorcycle	0,29	2,28
Automobile	0,017	0,14
Public transportation	0,07	0,55

Figure 4.7.5. Comparison of the overall government summation in relation to the average wage per hour in Ile-de-France

Source: Created by the author

Note: 1. Overall government summation is made up of public expenditure and external costs, from which specific revenues are deducted.

4.7.3. Lessons from comparisons

There are three points to remember when comparing modes and metropolises:

- For public authorities, public transport is always more expensive than the car, even when external costs are taken into account. While this is worth noting, it is not worth condemning public transport. It is the only means of mass transportation in the centres, and it is, for some time to come, the only one that can do without oil. On the other hand, this observation raises questions about supply and fare policies: the cost to the public authorities must be reduced if these systems are to be developed.

- The very high public cost of motorcycles in Ile-de-France, and their low private cost, are partly the result of an arbitrary allocation of the costs of insecurity. The perception of insecurity is very real for users, which is one of the reasons for the low rate of motorcycle use in Ile-de-France. Given the private (guaranteed journey time and lower monetary cost than the car) and public (low space occupation) advantages, a policy to make the use of this mode more secure has its place in a sustainable development perspective.

- The low average cost of PV use for the public authorities should not make us forget that this cost is high in dense centres. A policy that strongly differentiates the costs of use between central and peripheral areas is desirable.

- Finally, bus fares seem to be quite inconsistent in Ile-de-France. With a higher cost than that of PV and the subway, it cannot play the role it could in a sustainable development perspective.

Mode	Unit	Accidents	Victims	
			Dead	Wounded
Car	vkm (billion)	43		
	Insecurity	9669	208	9165
	Insecurity / vkm	225	5	213
Motorcycle	vkm (billion)	1,627		
	Insecurity	5943	153	9668
	Insecurity / vkm	3653	94	5942
Total	vkm (billion)	44,627		
	Insecurity	20201	361	18833
	Insecurity / vkm	453	8	422
Advantage between motorcycle and PV		**Motorcycle > Car**	**Motorcycle > Car**	**Motorcycle > Car**

Figure 4.7.6. Comparison of road accident rates related to motorcycle and PV modes in Ile-de-France

Source: Created by the author

4.8. Concept of generalized speed of transportation

The generalized speed of transportation takes into account the travel time and also the working time needed to pay for the trip. Proposed more than 30 years ago, this concept is still presented today as a radical criticism of the automobile, since from this point of view, a motorist would go much slower than a cyclist. This section first recalls the limits of such a reasoning, then explains the determinants of generalized speed, then shows that the speed of motorists is now higher than that of cyclists and that, above all, this analysis does not call into question the interest of increasing speeds indefinitely, as the standard economic calculation postulates without sufficient foundation. In order to find a more coherent reasoning, it is finally proposed to take into account the negative external effects of speed in generalized speed, in order to arrive at an optimal speed.

4.8.1. Introduction

In the early 1970s, Ivan Illich, a leading critic of industrial society, popularized the idea that, by taking into account not only travel time but also the working time needed to pay for the trip, the motorist would end up going much slower than the cyclist. This is what others later called "generalized speed" in reference to the concept of generalized cost. Despite the virulence of this criticism, the debate never really took place: it was hardly taken up by the scientific community, remaining more or less confined to alternative environments.

This section would first like to explain the reasons for this by recalling the known limits of this reasoning. Then, it will propose a formalization of the concept which will show that, contrary to appearances, the criticism does not concern speed: the generalized speed of motorists is now even higher than that of cyclists. Finally, it is a classical analysis of the costs and benefits of speed that could, by demonstrating that optimal speed necessarily exists, pave the way for a renewed and more coherent criticism.

4.8.2. State of knowledge

It boils down to little, because, despite research in French, English and German literature, no academic work seems to have been devoted directly to this subject, even though allusions to Illich's reasoning are not uncommon when the question of speed is addressed. It is true, as we shall see, that objections to this reasoning are important. And in fact, only a few relentless bicycle promoters have clung to this analysis and tried to enrich it. Let's detail the history of this debate.

4.8.2.1. At the origin of the concept

The demonstration that "the generalized speed of the automobile is, in general, lower than that of the bicycle" has been made for the first time more than 40 years ago (Dupuy, 1975). The conclusion of this pioneer work was: "Far from being a time-saving instrument, the automobile appears in this light as a time-consuming monster.".

The calculation was explained as follows:
"All annual expenses related to the ownership and use of an automobile are estimated.... These expenses are converted into time by dividing them by hourly income: this time is therefore the time it takes to work to obtain the resources needed to acquire and use one's car. It is added to the time actually spent travelling. The latter is estimated on the basis of the average annual mileage, the distribution of this mileage into types of trips [...], the intersection of this distribution with a distribution according to types of speeds [...] and an estimate of these speeds. Finally, for the record, we add the other times related to the use of the car: time spent personally on maintenance, time lost in traffic jams, time spent buying gas and various accessories, time spent in the hospital, time lost in incidents, etc. The overall time thus obtained, put in relation to the annual mileage, makes it possible to obtain the generalized speed sought.

The results are as follows, for different socio-professional categories, different municipalities of residence and different vehicle models, including the bicycle (the performance of the latter being calculated obviously according to the same principle). The data are relative to the year 1967 (cf. Figure 4.8.1) (Dupuy et al. 1976).

Socio-professional category	**Bicycle**	**Entry-level car**	**Mid-range car**	**High-end car**
		Citroën 2CV	*Simca 1301*	*Citroën DS21*
Senior executive (high revenue) (km/h)	14	14	14	12
Employee (medium-high revenue) (km/h)	13	12	10	8
Worker (medium-low revenue) (km/h)	13	10	8	6
Agricultural employee (low revenue) (km/h)	12	8	6	4

Figure 4.8.1. Generalized speed first results

Source: Dupuy, 1975

The calculations are very elaborate and difficult to contest: the cost price per kilometre is detailed by type of vehicle, hourly wages by socio-professional category, and speeds and distances travelled by type of network (Debouverie et al., 1974b).

The idea was taken up and popularized by Illich, who gave it worldwide resonance. According to him: "The average American spends more than 1,600 hours a year in his car [...], whether he uses it or earns the means to do so [...], to travel 10,000 kilometres [per year]; this represents barely 6 kilometres per hour." (Illich, 1975).

Such results are quite "staggering" - an adjective often used to describe them - because they seem to undermine the whole point of using a car or, more precisely, of making faster journeys thanks to it. This "production detour" consisting of "losing time to gain time" ultimately appears derisory (Dupuy, 2001). This is undoubtedly a "radical criticism", as stated in a review of controversies over the automobile (Orfeuil, 2000). Moreover, the most critical analysts of contemporary society have never failed to point it out (Gorz, 1973; Robert, 1980; Latouche, 2004).

4.8.2.2. Some limits to this reasoning

However, transportation specialists have not been moved by this criticism. It is true that from the outset and has been pointed out the main limitation to such a reasoning (Dupuy, 1975) :
"The calculation assumes substitutability between travel time and working time. Of course, in the short term, this condition is not met. We have to move in a social space-time that is what it is, with its constraints that we do not question. The existence of these constraints gives a very heavy weight to the time savings that a high effective speed of travel allows in the short term. Despite its high cost, travel by car may therefore be preferable in the short term, without this being at all incompatible with the fact that the car wastes time compared to a situation in which we would be free of these constraints."

Other authors have since clarified what increased speed can bring (Orfeuil, 2004):
"Time is not only quantity, it is also rhythm, and "buying time" (by buying a car) to "go fast" at other times is not absurd. Illich's critique makes an economy of the potential for creativity allowed by autonomy (it's up to you to invent the life that goes with it, as an advertisement for the Twingo reminded us), which will make the automobile take on new forms of mobility that neither public transport nor the bicycle allowed, and which, aggravating the situation, can, in certain configurations, lead to savings (from supermarkets to urban sprawl...)."

Also, speed "allows "maximizing" access to all urban resources, including land and housing, which density, in an economic system dominated by free trade, does not provide because of land pressure." (Beaucire, 2006). It is explained that "the spatial diffusion of resources [allowed by increased speed] makes it possible to achieve other social aspirations: the reduction of promiscuity, the diversification of living environments, property, aspirations that are themselves linked to the standard of living and the value system."

Therefore, speed is not just a matter of time, travel or work, it is also the means to access more and more varied resources and that is what makes it so attractive.

Another strong limitation of the analysis was also pointed out (Dupuy, 1975):
"A second hypothesis on which the calculation of generalized speed is based is that one hour of work = one hour of travel, with this hour being experienced as a cost." Now, "Although working time is considered as a time-tribute [or constrained time] in the same way as travel time, there is in it a dimension of social integration, of participation in the general activity of production, which is not present in travel time, which is only a forced complement to the previous one."

It's hard to imagine spending hours travelling by bicycle - a mode of transport that is often more strenuous and less comfortable than the car - to save time at work. Moreover, at the same time, it has been revealed as soon as the early 1970s the remarkable long-term constancy of "transportation time budgets": whatever the development of transportation, we always spend about one hour a day travelling (Zahavi, 1973). This conjecture has since remained generally valid. The trade-off between the two types of time seems in fact singularly limited.

Finally, the reasoning is based on averages for both rural and urban travel, which have very different characteristics, masking great disparities. Thus, for a motorist who uses his vehicle a lot on interurban routes, there is no doubt that his generalized speed would be much higher than that of a cyclist.

In short, the equivalence between travel time and working time is not self-evident and it may seem absurd to use it. However, the concept of generalized cost - widely used in traffic forecasting models, both to determine modal split and to allocate traffic to transport infrastructure - makes a very similar calculation. It is assumed that the cost of transport and the cost of travel time can be aggregated, and that users' trade-offs between these two costs to choose the most efficient mode of travel (particularly in price-time models to estimate the distribution of users between rail and air, between day and night trains, or between car and public transport), as well as to choose the best route (Wardrop principle). Similarly, if the generalized speed of the motorist seems derisory compared to that of the cyclist, the generalized cost of the motorist is no more glorious compared to that of the cyclist. For the same distance travelled, it was usually much cheaper to travel by bicycle than by car in the late 1960s. In short, the criticisms of the concept of generalized speed are just as much concerned with the concept of generalized cost.

4.8.2.3. Recent developments

In recent years, a few rather scattered works by heterodox authors have attempted to update or deepen the analysis of generalized speed (Dupuy, 2001; Vaillant, 2001; Kifer, 2002; Cheynet, 2003; Tranter, 2004).

From these recent developments, we will first recall this affirmation (Dupuy, 2001):
'The average Frenchman spent more than four hours a day with his car, either moving from one place to another with it, pampering it with his own hands, or, more importantly, working in factories or offices to obtain the resources necessary for its acquisition, use and maintenance. Returning recently to the data we had gathered to make this calculation, I have come to the conclusion that the present situation is no doubt worse than it was twenty years ago. If we divide the average number of kilometres travelled, all types of trips taken together, by this duration (or "generalized time"), we get something of the order of a speed. This speed, which we have named "generalized", is about seven kilometres per hour, a little higher than the speed of a man walking, but significantly lower than that of a cyclist."

A remarkable formalization has been proposed the same year (Vaillant, 2001). Another calculation was carried out, which is very well supported and here summarized in Figure 4.8.2. (Tranter, 2004):

	Luxury car	4x4	Average car	Cheap car	PT	Bicycle
Annual costs (1)	14161	17367	9753	5857	966	500
Annual working time to pay these costs (h)(2)	644	790	444	266	44	23
Average travel speed (km/h)	45	45	45	45	25	20
Annual travel time (h)	333	333	333	333	600	750
Annual time for complementary activities (h)(3)	51	51	50	51	60	55
Total annual time (h)	1028	1174	827	650	704	828
Generalized speed (km/h)	14,6	12,8	18,1	23,1	21,3	18,1

Figure 4.8.2. Calculation of generalized speed

Source: Tranter, 2004

Notes: 1. Australian dollars. 1A$ ≈ 0,60€ ≈ 70¥
2. Based on an annual income of A$40,100
3. Walking to the vehicle, maintenance, etc.

His results lead to a generalized speed for the automobile much higher than that which Illich and Dupuy had found in their time, without him drawing any lessons from it, because for him the main conclusion remains as edifying as ever: the motorist does not really go faster overall than the cyclist.

In the course of this brief history, obvious shortcomings have become apparent in both the analysis and the measurement of generalized speed. It would be useful to clarify the relationship between generalized cost, time and speed, to better understand the parameters that determine them and how generalized speed is changing. For this, an effort of formalization is necessary.

4.8.3. Formalization

Curiously, with the exception of the pioneering but succinct work of Vaillant, this formalization has never been carried out. However, it does not present any difficulty and allows for a better understanding of the limits of the analysis.

4.8.3.1 Mathematical expression of generalized speed

One cannot define generalized speed without recalling at the same time what generalized cost is and the generalized time from which it derives directly, as already explained by Dupuy.

The generalized cost is the sum of the private cost of travel (Cp) and the cost of travel time (Ct). This first cost is the product of the distance travelled (d) and the cost per kilometre (k). And the second is the product of travel time (Td) by the value of time often assimilated to the hourly wage (w). It is beyond the scope of this work to discuss the values of time, a considerable and already widely debated subject (Boiteux, 2001; Carnis, 2003).

The generalized cost can then be converted into time expenditures to obtain a "generalized travel time" (Tg) defined as the quotient of the generalized cost (Cg) by the hourly wage (w). This generalized time can also be decomposed into travel time (Td) and working time to pay for the private cost of travel (Tw).

Finally, the ratio between the distance travelled (d) and this generalized time defines the generalized speed (Vg). This is different from the average speed, which is the ratio between the distance travelled (d) and the travel time (Td), considering however, as Illich and Dupuy do, that mode access and waiting times are negligible (which excludes the case of public transport from the analysis) and that the arduousness of bicycle use does not alter the perception of cycling travel time. The three concepts are articulated as following:

$$\mathrm{Cg} = \mathrm{w}^* \mathrm{Tg} = (\mathrm{d}^*\mathrm{w})/\mathrm{Vg} \qquad \mathrm{Tg} = \mathrm{Cg}/\mathrm{w} = \mathrm{d}/\mathrm{Vg} \qquad \mathrm{Vg} = \mathrm{d}/\mathrm{Tg} = (\mathrm{d}^*\mathrm{w})/\mathrm{Cg}$$

And with a few simple calculations, it is possible to express these three concepts using the four basic parameters of average speed (V), distance travelled (d), cost per kilometre (k) and hourly wage (w), and then understand how they change with each of these parameters. Figure 4.8.3. summarizes the overall results.

	Generalized cost	**Generalized time**	**Generalized speed**
Definition	Cg = Cp + Ct Cg = (d*k)+(w*Td) Cg = d (k+(w/V)	Tg = Td + Tw = Cg/w Tg = d ((1/V)+(k/w))	Vg = d/Tg = (d*w)/Cg Vg = 1/((1/V)+(k/w))
Consequences	Cg>Cp Cg>Ct	Tg>Td Tg>Tw	Vg<V
When d ↑	Cg ↑	Tg ↑	Vg →
When w ↑	Cg ↑	Tg ↓	Vg ↑
When k ↑	Cg ↑	Tg ↑	Vg ↓
When V ↑	Cg ↓	Tg ↓	Vg ↑
When V → 0	Ct →∞ Cg →∞	Td →∞ Tg →∞	Vg → 0
When V →∞	Ct → 0 Cg → Cp	Td → 0 Tg → Tw	Vg → w/k

Cg: generalized cost of transport	Vg: generalized speed
Cp: private cost of travel	V: average speed (V=d/Td)
Ct: travel time cost	k: cost per kilometre
Tg: generalized travel time	d: distance travelled
Td: travel time	w: value of time (≈hourly wage)
Tw: working time to pay private cost	

Figure 4.8.3. Cost, time and generalized speed

Source: Created by the author

The definition of the generalized velocity of displacement is therefore summarized by the following formula:

$Vg = 1 / ((1/V) + (k/w))$

This means that the generalized speed depends on only three parameters: average speed, hourly wage and cost per kilometre. Vehicle Occupancy Rate (VOR) should be carefully considered. In this case, $Vg = 1/\{(1/V) + [k/(w*TO)]\}$. However, only occupied assets should be included in this occupancy rate. Therefore, taking this into account is difficult due to a lack of data and would hardly change the results. It does not depend on the distance travelled, since both components of generalized travel time are proportional to the distance travelled. However, it cannot be concluded, as some authors do, that generalized speed is constant when the transport time budget is stable.

$Td = d/V$ and $Tw = (d*k)/w$

It is now necessary to study how the generalized speed evolves according to these three parameters.

4.8.3.2. Average speed and generalized speed

In the short term, when the user seeks to take advantage of the time savings allowed by the increase in average speed without changing destination, the generalized speed increases, but is, by definition, always lower.

$Vg < V$, because V, k and $w > 0$

And the higher the speed, the more the generalized speed deviates from it. Because, if at low speed the travel time is very high in relation to the working time, as the speed increases the travel time is greatly reduced and the working time becomes predominant. This is why generalized speed tends towards the ratio of hourly wage to cost per kilometre, which is a generalized speed limit that cannot be exceeded.

When $V \rightarrow \infty$, $Vg \rightarrow w/k$

Finally, and this is the main point, the generalized speed is a hyperbolic function, therefore strictly increasing, with respect to speed (Figure 4.8.4). Even if generalized speed always increases less rapidly than speed (which many authors point out), it never ceases to increase (which they forget to specify), whatever the distance travelled. Thus, increased speed in the car always "saves time", even if the overall gain in speed is small. It is only in relation to cycling, and mainly in urban areas, that the use of the car "wastes time", not in absolute terms.

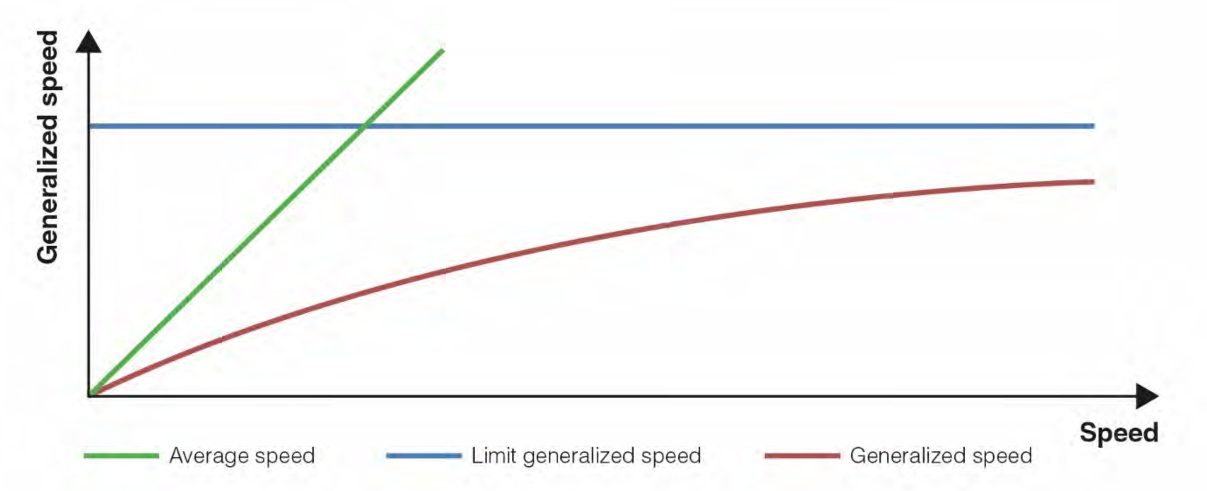

Figure 4.8.4. The evolution of the generalized speed as a function of speed

Source: Created by the author

However, this result is valid in the short term, when the user does not change his destinations. In the longer term, the user generally forgoes time savings and prefers to take advantage of the increased speed to increase the range of his or her trips and the number of accessible destinations. The result is a wider choice of jobs, shops, services, recreation, and social relationships, thereby improving user satisfaction and economic and social efficiency (Poulit, 2005).

Thus, whether the user chooses to take advantage of time savings or more distant travel, the result is the same: speed appears in an eminently favourable light and the concept of generalized speed does not alter this conclusion. On the other hand, this is not the case for both private and generalized costs, which certainly decrease in the short term with the reduction in travel time, but increase in the long term with the length of the trip at constant travel time. This has implications for the transport budget of those who choose to settle in the periphery (Orfeuil et al., 1999).

Admittedly, the inclusion of the negative external effects of transport in private costing does reduce generalized speed somewhat (Tranter, 2004). However, here again, it remains an increasing function of speed. This is because economists consider, often implicitly and to simplify calculations, that these effects do not depend on speed, at least for small variations, but only on traffic intensity measured in vkm (Baumstrark, 2003). This may be true for noise, or even pollution, but not for accidents or congestion.10 This is not true for accidents or congestion. In addition, many other external effects - not taken into account because they are difficult to assess and yet not negligible - are strongly dependent on speed, such as urban sprawl or social segregation; we will come back to this point later.

4.8.3.3 Cost per kilometre, hourly wage and generalized speed

Generalized speed increases with the hourly wage rate (or labour productivity) as the amount of work time required to pay for travel is reduced. Thus, all other things being equal, high income earners benefit from high generalized speed, but this applies equally to motorists and cyclists. And employees whose wages increase during their working life, or thanks to the general increase in real wages, are also gradually gaining access to it, as has been the case in many countries for half a century.

On the other hand, the generalized speed evolves as an inverse function of the cost per kilometre or cost of use of the vehicle. Thus, with equal incomes, those with powerful but expensive cars (and therefore high cost per kilometre) have lower generalized speed. Conversely, those with low incomes are forced to use inexpensive or used vehicles to achieve acceptable generalized speed. But when the real price of vehicles, automotive services, or fuels decreases, generalized speed increases and everyone benefits.

Finally, an increase in wages combined with a reduction in the cost per kilometre strongly reduces the "work equivalent price" of travel. This raises the generalized speed and its upper limit (w/k) in the same proportion.

4.8.3.4. Evolution of generalized speed over the past 40 years

Between 1967 (the reference date for Dupuy calculations) and today, what has been the evolution of the three parameters used to calculate generalized speed? Here is a rough estimate.

The average speed of passenger vehicles is very poorly known, but may have increased by as much as 30%. Indeed, urban areas benefited from a national plan to assist in the implementation of traffic plans during the 1970s (TEC, 1973) and then benefited from the construction of a network of urban freeways and expressways. Thus, in Ile-de-France, a region that nevertheless concentrates more than 80% of French road congestion, the increase in passenger vehicle speeds was 12% between 1976 and 2001, or perhaps 20% in 40 years. In provincial conurbations, where household travel surveys have not measured speed since 1976, it is probably much higher: in Grenoble between 1966 and 1973, it is estimated to have increased by 40%. In any case, between 1982 and 1994 (dates of the last two national transport surveys), the average travel speed for local mobility (less than 80 km) increased in France by 31% (Gallez, 1997), but this concerns all modes and takes account of modal shifts. As for long-distance journeys, they have benefited from a motorway network that increased from 1,000 to 10,800 km between 1967 and 2005.

Hourly wages in constant euros grew by approximately 110%, as average annual net salaries in constant euros increased by 74% between 1967 and 2004 and the annual working time has been reduced by 18%.

Finally, the cost per kilometre in constant euros fluctuated but remained stable overall. Indeed, according to an INSEE study (Bonotaux et al., 2000), in 20 years, from 1979 to 1999, "the price index of automobile-related consumption was multiplied by 2.2, an increase similar to that of the general index 2.1", because "price growth was lower for new cars and much higher for maintenance, accessories and repairs." In particular, the cost per kilometre of automobile fuel in France fell by 15% in constant euros between 1978 and 2005. In addition, despite increased travel distances and car ownership, household consumer spending on transportation (most of which is for travel in private vehicles) has remained at around 15 to 16% of total consumer spending.

As a result, in 40 years, the generalized speed in cars has increased in France by about 80% and the generalized speed limit by about 110%. Generalized time has been reduced by more than 40%; and the same is probably true in other developed countries including Japan. However, this trend has slowed sharply in recent years, with a much slower increase in hourly wages, a trend that is now more or less upward in the cost per kilometre with the rise in fuel prices and an average speed that is stagnating, due to the reduction in excessive speeds on the road network as a result of the introduction of the automated penalty control system with the increase in the number of speed cameras, the slowdown in new infrastructure construction programs and traffic calming policies in cities. Tranter even estimates that it should even decrease in the future, at least in Australia.

For bicycles, average speed may have increased slightly with lighter, more efficient bicycles and some bicycle facilities. Hourly wages for cyclists likely grew in the same way as for motorists (+110%). And the cost per kilometre has undoubtedly fallen a little with the increased productivity of the cycle industry, but it is also much better known and turns out to be much higher than we thought, at €0,12/km (2000 value) (Papon, 2002). This imprecision is, however, of little consequence, because for the cyclist, the share of the cost per kilometre in the generalized cost is low (one fifth to one tenth), whereas for the motorist, it is about half: a little less in the countryside and a little more in the city. As a result, the generalized speed of cyclists has hardly changed.

In total, the generalized speed of the motorist, who 40 years ago was still a third slower than that of the cyclist, is now a quarter faster. This is confirmed by recent calculations by Tranter. Whereas for Dupuy was in the order of 4 to 14 km/h for cars and 14 km/h for bicycles, it is now about 13 to 23 km/h for cars and 12 to 18 km/h for bicycles, depending on the hypothesis used for the cyclist's speed. Indeed, Tranter retains a high speed of 20 km/h, which it justifies by assuming that "the cyclist is a daily user and is therefore very sharp". Debouverie and Dupuy estimate it to be 15 km/h. In fact, according to various concordant sources (Bracher, 1987; Campbell et al., 1992), it is more likely to be 14 km/h at least in Europe.

In conclusion of this section, this work of formalization makes it possible to clarify the scope of Dupuy and Illich's criticism on the question of speed. It is necessary to face up to the fact that their reasoning does not in any way call into question the endless search for ever greater speed, which moreover appears to be beneficial in all cases, both in the short and long term. Worse, since the generalized speed of motorists is now generally higher than that of cyclists, the argument turns against their authors and justifies, 40 years later and in most cases, the use of cars rather than bicycles. To save, in part, Illich and Dupuy's reasoning, it is, however, possible to distinguish the environments crossed: if in rural areas the generalized speed of the bicycle is today much lower than that of the car, in urban areas it remains, in the end, much higher.

4.8.4. Towards a cost-benefit analysis of speed

To find a more coherent discourse on speed, we need to look more deeply into its costs and benefits. This is precisely what is included in the little-known concept of "optimal speed", which has been used for a long time by some authors: "Individual optimal speed (V*) is defined by equalizing marginal income to marginal cost. Any traffic speed above this optimal level necessarily results in a greater increase in costs than in earnings." (Carnis, 2003)

4.8.4.1. The existence of an optimal speed

On reflection, it is obvious that it makes no sense to consider an indefinitely favourable impact of increased motorized transport speed on overall speed. It is not the purpose of this paper to demonstrate this fully, but to sketch out this line of research.

First of all, from a purely technical point of view, all nuisances without exception vary, and often strongly, according to speed. On the one hand, they all increase beyond 30 to 60 km/h. This is true not only for the most studied nuisances: noise, pollution, accidents, congestion (OECD, ECMT, 2007), but also for the "invisible harms of speed" of transport (Wiel, 2006), such as urban sprawl and social segregation or other impacts such as severance effects, space consumption, and disqualification of nonmotorized modes (Héran, 2000). On the other hand, some nuisances increase, on the contrary, when speeding becomes very low: pollution, congestion, space consumption. According to the most recent work, the strict application of the speed/pollution curves of the Copert type greatly overestimates the pollution generated by calmed traffic. This is because urban cycles are quite different, with fewer accelerations and speed changes (Panis et al., 2006). This also justifies the use of other modes at this speed: walking, cycling, electric cart, scooter, etc. Thus, from the sole point of view of the real impacts, there is necessarily an optimal speed that minimizes the nuisance of individual motorized vehicles, and which is different according to the size of the local populations concerned and therefore according to the city and the countryside.

Second, in economic terms, the monetary benefits in terms of short-term time savings (assumed to be equivalent to longer-term accessibility gains) are offset by fuel and nuisance costs (accidents, noise and pollution) that increase more than proportionally with higher speeds. Using this reasoning and calculations based on marginal costs, it has been determined an "optimal speed for light vehicles on the French interurban network" (excluding freeways) of about 84 km/h, which is close to the speed limits in force (90 km/h on roads outside built-up areas and 110 km/h on dual carriageways) and the average speeds used (see ONISR's balance sheets), thereby justifying the road safety and pollution reduction policy (Carnis, 2004).

However, such work does not seem to have been carried out in built-up areas where the situation is much more complex and where transport nuisances are much higher and, above all, more varied. In this environment, speed-related impacts such as noise, cut-off effects, space consumption, social segregation, or urban sprawl cannot be considered negligible. The impact of speeding on the environment is also a major factor. Finally, the benefits of increased speed can itself be criticized, for at least five reasons.

1) It should be remembered that speed does not increase the number of journeys and therefore the opportunities for encounters, which remain quite stable in the long term (Zahavi, 1973; Orfeuil, 2000), but only the scope of journeys and the choice of destinations. Moreover, a distant trip is no more useful than a local trip, since only the activity carried out at the destination counts.

2) One can seriously question the need today to further broaden the universe of choice for consumers, job seekers or businesses, as advocated by standard theory (Poulit, 2005). Reducing the adequacy of supply and demand in the various markets to a simple question of a more or less extensive choice of goods or services is, on reflection, somewhat simplistic. Today, in most cases, the choice is already considerable and its enlargement no longer appears so decisive. We have entered a society of hyperchoice, which is not without perverse effects: difficulty in orienting oneself in this universe, and sometimes even renunciation of choice, or even of consumption (Schwartz, 2004). Other aspects obviously play a much more crucial role: the quality of goods and services and, more broadly, the construction of relations between suppliers and demanders.

3) Human density (inhabitants + jobs per ha) remains a powerful means of increasing accessibility: despite much higher travel speeds on the outskirts than in the centre, periurban dwellers can access fewer destinations than central residents or employees in a given travel time. It is therefore always more attractive to live and work in dense areas if one wants to take advantage of a wide variety of contacts. This is why so many households and businesses want to continue to locate in or near the centre, despite slower travel and high land costs.

4) In this regard, the argument that speed is a way of escaping land pressure is greatly weakened when one realizes that the overall budget devoted to housing and travel hardly varies between areas close to the centre and the greater periphery, nor even the amount of housing available per person (Orfeuil et al., 1999).

5) Finally, major transport infrastructure certainly improves remote accessibility, but to the detriment of close accessibility because of the numerous effects of territorial isolation that it causes. It is often simpler and less dangerous to cross the city by car than to walk or cycle from one neighbourhood to another (Héran, 2000).

As a result, there is a range of different optimal speeds for different individuals, different types of networks and different urban and rural environments, allowing the costs and benefits of speed to be reconciled. Just as it is possible to reason globally about a generalized speed that in fact masks enormous disparities between individuals, networks or environments, it is possible to conceive of an optimal speed that of course has the same reductive character of these disparities. However, to recognize this, we need to take down from its pedestal the speed that centuries of conquest have made sacred (Studeny, 1995) and admit that there are what we should call the "negative external effects of speed".

4.8.4.2. Generalized social speed and optimal speed

It would appear theoretically possible to enrich the economic analysis by internalizing the negative externalities of speed in the private cost, so as to obtain a "social cost" that can be integrated into a "generalized social cost" and a "generalized social speed". Consequently, the evolution of generalized social cost as a function of speed has a minimum and generalized social speed a maximum corresponding for the car to the optimal speed (which should be called more precisely the "optimal generalized social speed").

For the bicycle, there is no optimal speed, but a speed limit linked only to the physiological limits of the cyclist. In other words, it is always in a cyclist's interest to ride as fast as possible (Papon, 2002).

From a formal point of view, social generalized speed depends on the social cost per kilometre (ks), which incorporates the negative impacts of speed. It is not possible to specify the shape of the relationship of ks as a function of speed without extensive investigation. It could, however, be of the type:

$$ks = a/V + bV + cV^2$$

In order to incorporate impacts that are inversely proportional, proportional, and more than proportional to speed, with parameters (a, b, and c) yet to be determined. Therefore:

$$Vgs = 1/((1/V) + (ks/w))$$

and the optimal speed is reached when the first derivative of the generalized speed social to speed is equal to zero:

$$\partial Vgs/\partial V = 0$$

Figure 4.8.5 represents this formalization:

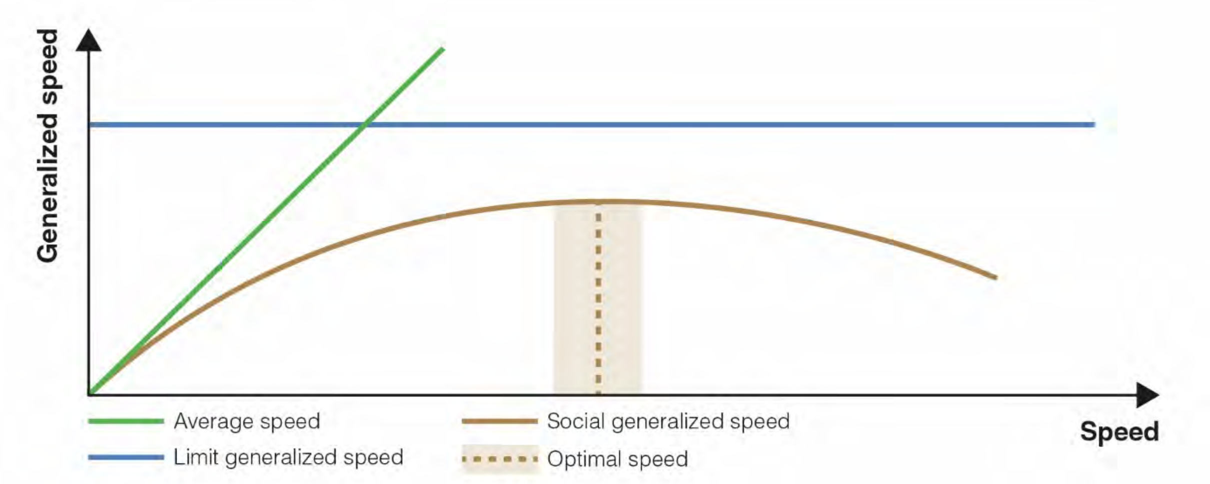

Figure 4.8.5. Generalized speed as a function of speed when the negative external effects of speed are internalized

Source: Created by the author

While it is likely that an optimal speed exists, in practice, however, it will be very difficult, if not impossible, to determine it in built-up areas. Firstly, because the impact of speed on certain nuisances is still very poorly known. For example, no one today knows how to precisely measure its impact on social segregation, even if it is undeniable (Mignot et al., 2006). Even the speed-pollution relationship is still very controversial. Secondly, it is not certain that the optimal speed is significantly lower than the speeds currently practised. However, it is nevertheless likely that there is a wide range of solutions close to the optimum (grey area in the diagram in Figure 4.8.5) and that a calculation error would therefore have relatively little impact. It is precisely for this reason that traffic calming policies would ultimately have little impact on the economic efficiency of cities. Finally, the question remains as to how this optimal speed should be distributed among the different types of networks with very different speed limits today (30, 50, 70 zones, expressways, freeways). There is no doubt that speeds should be harmonized downwards, while improving the permeability of the network (Dupuy, 1999).

4.8.4.3. Perspectives

Reasoning in terms of generalized speed has the great merit of revealing the enormous production detour that the use of the automobile imposes to "save time", as Dupuy rightly points out, and it forces us to question the economic and social relevance of such a destructive detour for our environment, which is both a predator of rare and non-renewable resources and a producer of nuisances that threaten the survival of the planet, via the growing contribution of transportation to the greenhouse effect. Nevertheless, the car saves more time than ever before, even more and more so than the bicycle. Revealing its widespread low speed does not call into question this result, contrary to what is generally asserted. Thus, the radicality of the criticism is not about speed, but about industrial society.

However, speed as such does indeed pose a problem for society: while its advantages are undeniable but often overestimated, it also causes numerous and exponential nuisances (noise, pollution, space consumption, cut-off effects, social segregation, etc.) above a certain threshold. It is therefore essential today to reflect in depth on the positive and negative effects of speed. It would be possible to show, at least crudely, using economic calculations, that there probably exists, both in interurban and urban travel and depending on the type of network, an optimal speed compatible with the development of economic and social activities and which leaves more room for autogenous modes that respect the environment and user-friendliness. The "control of speed in urban and peri-urban areas" (Wiel, 1999) or the "reduction of speed on the network" (Dupuy, 1999) demanded by many are not just intuitions; the traffic calming policies that are being developed are not purely electoral measures aimed at the privileged in central municipalities, but solutions that are rational. Perhaps one day this will one day be formally demonstrated.

4.8.4.4. Generalized speed calculation

The mathematical formulation of generalized speed and generalized speed limit can be derived directly from the three parameters of average speed, hourly wage and cost per kilometre, without the need for annual global assessments of various parameters, as is currently the practice (Dupuy, 1975; Kifer, 2002; Cheynet, 2003; Tranter, 2004). In addition, it is only in order to find the generalised travel time per year that it is necessary to know the annual journeys per vehicle. Finally, generalised social speed is obtained by determining the "social cost per kilometre" depending on speed according to a formula to be found (on this point, the following case is purely illustrative). See Figure 4.8.6 and the corresponding Figure 4.8.7.

The results indicate that the generalized speed of the car is slightly higher than that of the bicycle, and the generalized travel time by car is 2 hours 10 minutes per day. The fictitious formulation of the social cost per kilometre as a function of speed incorporates the negative external effects of speed. The social optimal speed in this case is a fictitious 34 km/h. Between 20 and 60 km/h average speed, the social generalized speed varies only by 10% around the optimum.

	Data / Calculation	Unit	Bicycle	Car
Average speed	V	km/h	14	40
Average net hourly wage of a French employee	w	€/h	12,1	12,1
Cost per kilometre	k	€/km	0,13	0,38
Generalized speed	Vg=1/[(1/V)+(k/w)	km/h	12,2	17,7
Generalized speed limit	Vgl = w/k	km/h	93,1	31,8
Annual trips per vehicle	da	km/year	2 000	13 800
Annual private cost of a vehicle	Cpa = da*k	€/year	260	5 244
Annual working time to pay the private cost	Twa = Cpa/w	h/year	21	433
Travel time per year	Tda = da/V	h/year	143	345
Generalized travel time per year	Tga= Tda+Twa	h/year	164	778
Generalized travel time per day	Tg=Tga/365	h/d	0,45	2,13
Social cost per kilometre	ks = (a/V)+bV	€/km		0,73
Generalized social speed	Vgs = 1/[(1/V)+(ks/w)].	km/h		11,8
Optimal speed	Vo = (w + a)/b	km/h		34

Figure 4.8.6. Generalized speed of bicycles and cars in France

Source: Bicycle speed (Bracher, 1987; Campbell et al., 1992), annual trips and private cost of cycling (Papon, 2002), annual car trips (Ministry of Transport, CCTN), private cost of the average car (ADEME), hourly wage (INSEE).

Note: a=5 & b=0,015 are values chosen as an example.

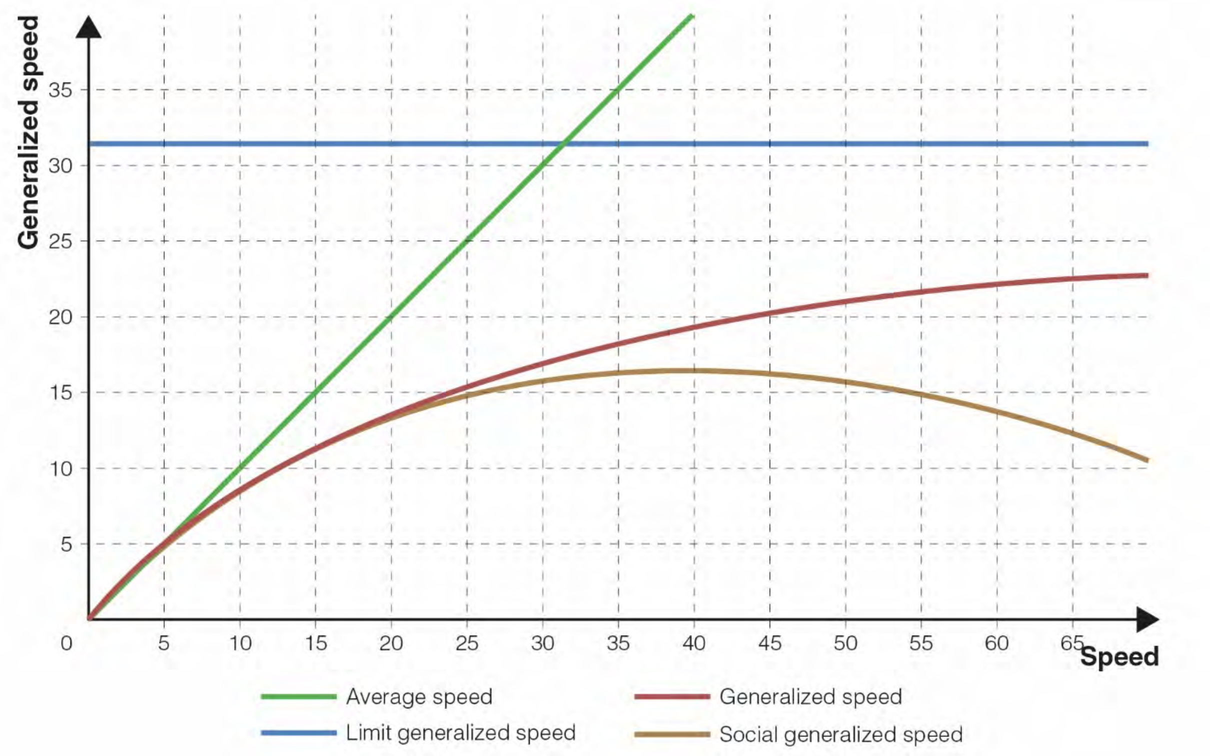

Figure 4.8.7. Graphical representation of generalized speed depending on the speed in the example studied

Source: Created by the author

Chapter 5

Urban influences

Based on the descriptions of transportation and the quantitative assessment of travel costs by activity in the second part, we were able to identify the respective characteristics of the costs of the modes for users, the government, and the environment.

The search for more sustainable mobility is now part of the common culture in the world's major cities. In the first part, we present the projects and prospects of these two metropolises. Our work on mobility and the costs associated with the use of means of transport, on the scale of metropolises or on the more disaggregated scale of types of link, also enables us to position the use of modes on a grid for assessing their contribution to the different dimensions (economic, social, financial, environmental, urban) of sustainable development. We present this grid in the following section, and position the interest of the use of modes, in the spatial context, in relation to the different dimensions of this grid. Finally, we will select a limited series of potential measures and analyse, according to the results, their relevance to sustainable mobility and intermodality.

Below we present the medium- and long-term urban transportation plans and their quantified targets for Ile-de-France and Yokohama. They show significant development costs for public transport networks. Next, we propose sustainable development perspectives based on our research calculations, more focused on fare reforms concerning parking and public transport pricing, which better integrate the issue of the financial sustainability of the systems.

5.1. The conditions for an alternative mobility to the private car

Today, the private car accounts for three-quarters of the kilometres travelled in France and 43% worldwide; it seems to have become the essential means of our mobility. But can we imagine another way of organizing our travel? Can we find places where we can do without them? If not, can we develop an alternative model, with what solutions - public transportation, non-motorized modes, intermodality? How can this be achieved and what are the necessary conditions?

Before thinking about the possibilities of developing an alternative offer to the individual car, we will first research the places where one would travel otherwise than by car. In order to deserve our attention, these places must naturally be inhabited, have a sufficient number of people, and allow this population to attend the various activities that take place there: in other words, we are particularly interested in cities. We will examine the various possibilities, initially by considering one after the other each of the main alternative modes (Papon, 2001).

5.1.1. Pedestrian and bicycle city

The city where walking is the main means of locomotion is the archetype of all the human settlements that developed from the Neolithic with Jericho (around 7000 BC, now the West Bank) and Çatal Hüyük (6800 BC, now Turkey) to the industrial era. Other means of transport were mainly used for the transport of loads (donkey, cart, boat) or of privileged people (sedan chair, horse, carriage). At that time, these cities always kept small dimensions to be walked and reached high densities. In 1800, people travelled mainly on foot in the largest city in the world, which was Beijing, with 1.1 million inhabitants. Today, this mode of organization is still found in a few towns in Central Africa or Papua, but almost all cities have other means of transport introduced since the industrial revolution.

In our developed countries, you can get an idea of what these pedestrian cities were like by walking around this remarkable site that is Venice. But make no mistake: the lagoon Venice is not an authentic pedestrian city today. It is a first-rate tourist site, an enclave within a larger urban ensemble, which extends as far as Treviso and Padua, and where daily journeys are ensured by a network of freeways and railways: for example, 55 million vehicles passed through in 2001 on the western tangential road of Mestre, which serves the Marco Polo airport. Thus, historic pedestrian cities have at best been transformed into museums where visitors can reach them by fast means of transport, at worst they have been sacrificed to the demands of the flow of car traffic.

Amsterdam is also known as the city of the bicycle (where, as at the national level, the bicycle accounts for 28% of all trips). Here the bicycle is not a means owned and used while waiting for a car, since the Netherlands has a level of motorization comparable to other industrialized countries. But in this country more than elsewhere and earlier than elsewhere, the constraints on private car use have emerged: lack of space and environmental damage. Amsterdam's canals were almost filled in to provide boulevards for car traffic. Fortunately, this did not happen, and the country implemented a restrictive car policy as early as 1975. In this context, the bicycle emerged as the most suitable alternative means of transport, especially as population density remained high in the cities, and local services were maintained. However, the bicycle should not be seen in Holland as an ersatz for the car, as was the case in France during World War II. But it is a key element of integrated urban planning and transportation policy in the Netherlands, and in many ways, it is exemplary: for example, the city of Houten (near Utrecht) has a road network that allows bicycles to go from one point to another by the shortest route, but forces cars to make long detours via the ring road.

However, while the modal share of cycling in the Netherlands is remarkable, in terms of distances travelled, the car provides the largest share of mobility, and as elsewhere, these distances travelled by car are tending to increase. Thus, on a country-wide basis, car travel distances per capita in the Netherlands are slightly lower than in France or Germany, but the difference represents only a few years of traffic growth. If we look at the city level, where much of the nuisance is concentrated, the differences are of course greater.

5.1.2. The city of public transportation: a stage or a renovation of motorization

If there is no such thing as a bicycle-only city, are there any cities whose mobility is entirely oriented towards public transportation? This was the goal of the former centrally planned economies, and they have succeeded in achieving a high level of public transport use. In 1985, for example, public transport accounted for 70% of all trips in Budapest, with sometimes outdated but diversified services covering the entire conurbation with metros, suburban trains, streetcars, trolley buses, buses and funiculars. Although the economic transition has been accompanied by considerable growth in the car fleet and, to a lesser extent, in traffic, public transport still accounts for the majority of trips. However, erosion has been much greater in smaller cities, such as in the former East Germany. This shows that the public transport system maintained at a very high level of use by a totalitarian government no longer necessarily corresponds to the aspirations of the population, for whom access to the car is almost synonymous with regained freedom, in a new context in which policies favour increased road provision. The predominance of public transport could therefore be seen historically as a stage before motorization. This is somewhat similar to what is happening in developing countries at a different pace. Buses initially provide a preponderant share of mobility in large metropolises, before individual motorization increases significantly: in Sao Paulo (Brazil), for example, private cars and buses were almost on an equal footing in 1997. In these countries, the bus is in the process of being dethroned by individual motorization, even though remarkable achievements have been made, such as the exclusive right-of-way bus systems in Curitiba (Brazil) or Bogota (Colombia).

But there are still cities in rich countries that have consolidated a significant share of public transportation in all-mode mobility: 60% in Hong Kong, but in a constrained location, 37% in Tokyo or Zurich[30]. In this case, this result is the result of a voluntarist but democratically chosen policy. The extreme case is that of the ski resort of Zermatt (Switzerland), where private cars have been voluntarily banned, and the last 6 kilometres to reach this city must be covered by train or on foot. Generally speaking, Switzerland has excellent public transportation services, the importance of which varies from city to city, and the share of bicycles is not negligible. This would tend to show that an alternative mobility to the car is possible, while channelling car flows and managing parking. At first glance, this transportation system could appear costly, for both the user and the community. However, controversies remain over the real long-term cost of the automobile[31]. Moreover, the Swiss are still heavy users of private cars, with 27 kilometres per person per day in 2000. While car use remains moderate in large conurbations, especially in the German-speaking part of Switzerland, for longer distances, it is tending to increase as elsewhere. Thus, public transport is only partially able to replace the car, but this is an interesting result for sustainable development, since much of this substitution takes place in cities where energy overconsumption, pollution and space problems are often concentrated. In addition, beyond the national averages, there are clear local disparities, which show an impact of supply on attendance.

[30] With, in this agglomeration, 35% for non-motorized modes and 27% for private cars.

[31] And public transportation networks, especially streetcars, can, as in Switzerland, be amortized over a long period.

5.1.3. The multimodal city: the compromise of reason

In reality, the real alternative city to the car is neither walking, cycling nor public transportation, but a mixture of all three. Because no mode taken in isolation can compete with the private car. In today's examples there is still, in any case, a part of the mobility provided by the car. Each mode is used for the trips for which it is most relevant. Moreover, for some trips, it is useful to link several modes together (intermodality). For example, in Tokyo, the world's largest metropolitan area today, public transportation, private cars, walking, cycling and intermodality all have modal shares of more than 15%. We can therefore review the historical significance of these alternative mobility cities that we have found. Before the industrial era, cities were all pedestrianized. At the end of the nineteenth century, various means of transport were introduced: train, metro, bicycle, car, bus, streetcar; but the cities that in the twentieth century developed with public transport or bicycle or both, were introduced during a transitional phase, before the development of mass motorization promoted by political orientations. The latter, which began in the 1920s in the United States, in the 1950s in Western Europe, in the 1960s in Japan, in the 1970s in Latin America, in the 1980s in Eastern Europe, and in the 1990s in Southeast Asia, crushed the other modes but posed formidable environmental and social problems. It was only in the most advanced cities at the end of the twentieth century that a harmonious development of the different modes of transport emerged. Therefore, we characterize the four phases of the locomotive transition, which is strongly related to the evolution of urban structure, and is illustrated most remarkably by the four largest cities in the world in succession (see figure below).

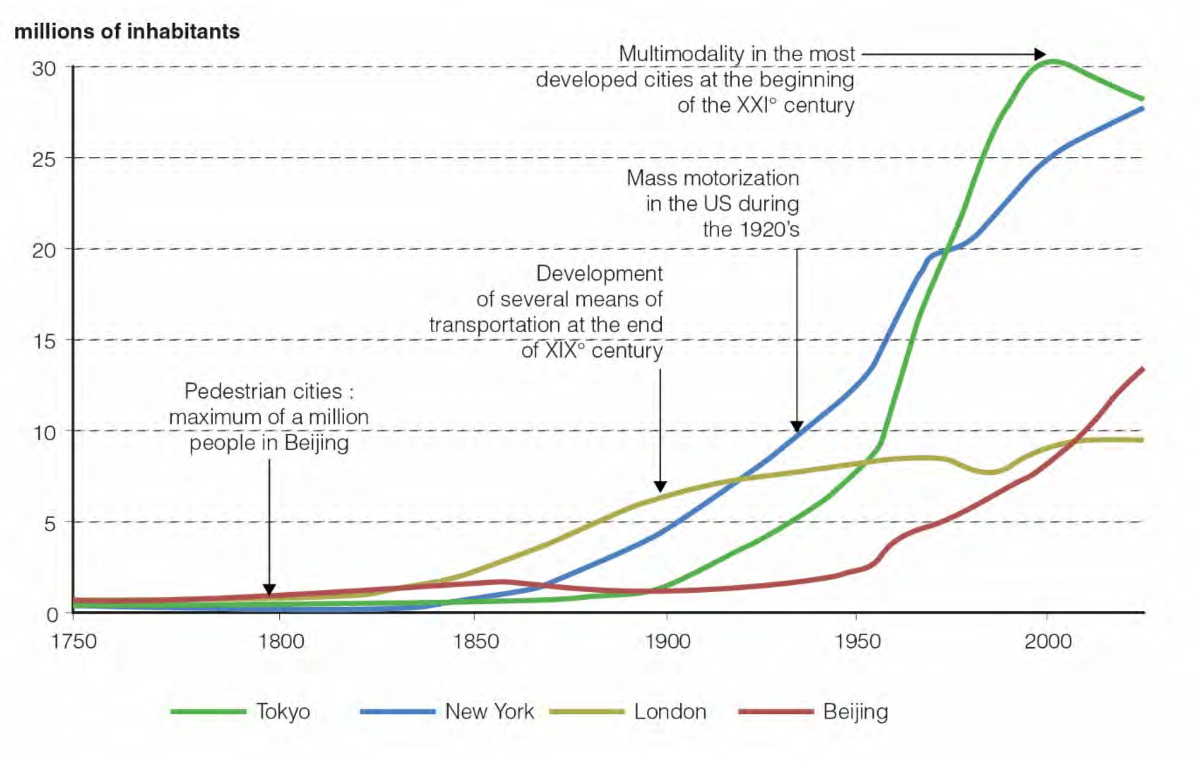

Figure 5.1.1. The world's four largest cities since 1750: four phases of locomotor transition

Source: Created by the author

The first condition for an alternative mobility to the individual car is the development of a credible alternative offer by combining several modes and promoting synergies between these modes. The basis of the alternative offer can be the combination of walking, cycling and public transport, complemented by motor vehicles used in contexts other than individual ownership: traditional cabs and rental cars, or new solutions such as car sharing or shared car ownership. Clearly, the development of a credible offer alone is not enough if the conditions are not in place for it to be used. Conversely, it is difficult to take measures to encourage the use of alternatives to the private car if a credible alternative does not exist. This is true even if the two aspects are partly closely linked: alternative modes are directly and indirectly disadvantaged by the increasing use of the private car (or by design choices that favour this increasing use) and, conversely, certain measures likely to curb the excessive use of the car are likely to favour (or less disadvantage) alternative modes. This is true even if it is not a question of substituting one mobility for another: the objective is not to systematically replace individual car trips with trips using another mode, but to enable the final needs of individuals to be satisfied both by another organization of activities and of the city, and by another organization of transport (in other words, mobility is not an end in itself, but a means of satisfying certain needs) (Fresnay, 1997).

Before dealing with the conditions that must be met to encourage a significant use of alternative modes, we will discuss the development of the offer in terms of quality and quantity. We will focus in particular on public transport, non-motorized modes and intermodality, leaving aside car sharing, which is dealt with in another article.

5.1.4. The search for "ideal" public transit

Without dwelling on historical considerations, a brief reference to attempts in recent decades to develop "new modes of transport" may be of interest; here we will limit ourselves to a typical case: the Personal Rapid Transit (PRT) concept, which originated some 30 years ago in the United States and has been studied in several industrialized countries. This concept alone claimed to represent an alternative model to the individual car within an urban area. The principle consisted in serving a meshed network with cabins or small vehicles of customized size (3 to 5 seats all seated), programmed on demand to offer direct service without stopping at intermediate stations. The aim was to compete with the automobile on its own terrain by offering a very high level of service quality and comfort: no or little waiting, high commercial speed, no load break, great interior comfort, personalized service. In France, this concept was represented by the initial version of Aramis (first prototype at Orly in 1971) which had a much more ambitious objective than the Aramis S studied in the 1980s for application on the small southern beltway of Paris. Despite the abandonment of the main projects in France and elsewhere, some studies have continued to this day, notably in American universities, but in general the PRT concept does not appear to be a credible alternative, notably because of the complexity of the networks to be built over vast areas, a huge vehicle fleet to absorb peak hours, etc. The PRT concept is not a credible alternative.

Today, public transport no longer appears to be able to provide a global alternative to the private car through the development of a new technological product creating a new mode of transport, intrinsically endowed with all the necessary qualities. On the contrary, if we want to significantly increase the use of public transport, we need to implement a whole set of diversified measures, both internal and external to the mode: transport organization, space allocation, urban planning policies, and regulations. However, although technological improvements should no longer be the primary focus, their contribution to overall network efficiency should not be overlooked in a variety of ways, depending on the context.

Just as the success of the private car can be explained by the synergy between a technical system that has been gradually and steadily improving for more than a century and an entire organization (of transport, territories, and activities) that is increasingly built around this technical system, the success of public transport cannot be achieved without a synergy between continuous improvement of the technical system and an organization of the city and other territories that goes hand in hand. However, the parallel between the two modes of transport comes up against a fundamental difference: whereas the individual car derives its strength, but also its energy and environmental weakness, from its universality (the same vehicle can be used indiscriminately in all types of cities or areas, in various configurations), public transport derives its weaknesses (e.g., load breaks, small vehicle runs) but also its potential strengths (specific adaptation, possibilities for optimization) from the fact that it is carried out differently depending on the sites under consideration. It is in this context that urban and peri-urban public transport equipment is diversifying: new categories of systems are emerging, described as automatic, hectometric, intermediate, interconnection, etc., which can be adapted to suit the needs of each site.

The new systems do not eliminate the old ones, but are added to the traditional categories of public transport, which continue to develop and are available in several variants:
- the bus and its gas, electric or hybrid transmission variants or its capacity variants ranging from microbus to megabus;
- the trolleybus and its dual-mode variants;
- the streetcar and its light rail variants, mostly developed abroad (e.g. "Stadtbahn");
- the metro with its variants of gauge, insertion (tunnel, overhead track, trench) and automation;
- the commuter train and its RER or S-Bahn variants; - the railcar and new TER equipment, light railcars, etc. (Soulas et al., 2002)

5.1.5. Five technical improvements that can be envisaged in the short term

Without attempting to be exhaustive and without claiming that these are the most fundamental aspects (since what is essential is not each individual measure taken individually, but the overall synergy of a large number of different actions), we will briefly describe five examples of improvements to technical public transport systems that can be achieved now or in the near future (Soulas, 2001).

5.1.5.1. First example: full automation

Its main advantage is the improvement of operating flexibility, which makes it possible to adapt supply to demand without being constrained by driver presence grids, by offering an attractive frequency of passage, including in the evening and even at night. Unlike the PRT concept, the aim is not to eliminate all connections and offer a personalized service, but to improve the attractiveness of public transportation while making connections less dissuasive, thanks to improved frequency of use. The absence of drivers is not synonymous with dehumanization, insofar as it can be accompanied by a greater number of flying intervention teams in contact with the public (when there is a problem of insecurity, it is not necessarily the driver alone in his cabin who can solve it; on the contrary, he is sometimes the target of aggression, which, moreover, is one of the causes of strikes).

The full automation of a guided transport line is not in itself a considerable additional cost, but the most expensive is the full own site, which is usually necessary to guarantee safe automatic operation. For example, full automation is already appropriate for lines where full exclusive right-of-way is required for capacity reasons, such as subways and light rail systems. A much wider diffusion of full automation will depend on the possibilities of insertion that are less costly than the tunnel, to be studied in interface with the city's development: light airways (for small-gauge silent systems), trenches, protected tracks on the ground with gradients at certain crossroads, or even automatic crossings below a frequency threshold. Certain types of insertion that are currently problematic could be more easily achieved in a city where car traffic would be very low and developments designed accordingly, giving priority above all to crossings for pedestrians, cyclists and commercial vehicles. It is interesting to note that, for the French systems alone, six different products have been developed, limited to those that have proven themselves in commercial operation on at least one line in France or abroad: the Val declined in several variants, Maggaly (Lyon), Meteor (Paris), PomaOtis (Laon and foreign projects), Axonis (Singapore), SK hectometric (Shanghai). With a view to developing an alternative mobility to the automobile, it would be possible to distribute the same system on a sufficient number of lines and to control costs.

5.1.5.2. Second example: improved surface guided transport

Let us now consider systems under manual control, whether they are conventional streetcars or the new wheel-guided systems. For surface networks, guided systems are to be preferred whenever possible for reasons of capacity, insertion (reduction of right-of-way), ease of electrification, accessibility (small vehicle/platform gaps). The need for capacity is justified by three interlocking reasons: line throughput in a changing context (in an alternative scenario the throughput of a public transport line must be able to be significantly higher than in a scenario where the car is the largely dominant mode), passenger comfort, operating costs.

So far, the reintroduction of light rail in France has been qualitatively successful on a few sites: modern vehicles with attractive designs, city beautification, partial or complete low floors facilitating access for various categories of passengers, and even attempts to remove catenaries in some areas. In order to significantly increase usage, it is necessary to link the network with several lines offering good frequencies, and therefore to focus on quantitative development, even if it means reducing unit investment costs through a combination of means:
- increase in the size of series and standardization of materials and components;
- Continuation of the efforts initiated to create systems (vehicles, tracks and equipment) with lower cost of ownership;
- taking into account a depreciation over a few decades;
- if necessary, less importance is given to the aesthetic aspects.

In recent years, wheel-guided systems such as the Civis, TVR or Translohr have announced significantly lower costs than the rail streetcar. However, this is not currently the case if we consider that the first generation Civis is only partially guided in the vicinity of stations, the dual-mode TVR has encountered major technical difficulties on the first line in Nancy, and the Translohr, the only real wheeled streetcar still guided, is no less expensive than a rail streetcar for its first application in Clermont-Ferrand. However, for the next few years, the wheeled streetcar represents a prospect that could enable us to go even further than the trends set by the rail streetcar in order to reduce costs, reduce rolling noise, especially in curves, and facilitate insertion.

5.1.5.3. Third example: light rail systems for suburban services

These are the interconnection streetcar or regional streetcars. One of the shortcomings often highlighted for public transport systems in their current configuration is their unsuitability to provide efficient suburban services. In fact, as soon as peri-urbanization is a little organized and not totally diffuse, several tools exist with conventional urban or regional public transport and with new light rail systems which can be realized in various configurations according to local contexts. A basic idea is to minimize the cost per kilometre of the new systems by reusing conventional rail rights-of-way, whether or not there is cohabitation with other types of trains (interconnection streetcar/tram-train) or not (regional streetcar/tram-tram).

The interconnection light rail system is operational in three German conurbations and is now ready for deployment in other countries, including France. The most important achievement is the "Karlsruhe model": it became known in 1992 with the opening of the first Karlsruhe-Bretten section, which was a resounding success. The increase in the number of passengers on the rail service was very significant, due to the simultaneous implementation of several factors to improve the offer: elimination of the connection thanks to the interconnection, improvement of the timing, creation of a few additional stops, new equipment. German specialist publications have often reported a 600% increase in ridership, based on initial traffic that was not negligible, since it exceeded 2,000 passengers per day. However, beyond this figure, which is a way of presenting the results to strike public opinion, it is interesting to note two things: - the demonstration of the impact of a significant improvement in supply; - the achievement of a modal shift from private cars to public transport for a suburban service (40% of new trips made come directly from the car, not to mention trips due to an increase in mobility, which could have been transferred to the private car if the transport policy had been different).

Since the opening of the first section in 1992, the tram-train network has gradually expanded and will continue to do so. It is integrated into the SBahn network which, with five lines with antennas, represents a length of around 400 to 500 km, not including urban streetcar lines or conventional regional rail services. In the Karlsruhe region, the quality of the public transport network, combined with highly developed bicycle intermodality and appropriate urban planning policies, have made it possible to limit car mobility, but no measures have been taken to restrict car traffic.

5.1.5.4. Fourth example: the bus as a transportation system

With a view to the development of an alternative offer to the private car, the bus must be replaced whenever possible by more efficient or more capacitive systems, but there will always be a large number of lines left. Vehicles can benefit from various technical improvements (new engines, low floors, modular interior layouts, etc.), but the most significant improvements in service quality are to be expected from a design as a real transport system integrating vehicle/infrastructure interfaces and operating equipment: - design of suitable pavements; - exclusive right-of-way that is truly protected from illegal parking (traditional permanent exclusive right-of-way or, where appropriate, for very low frequency lines, new virtual exclusive right-of-way solutions that travel with the bus) ; - traffic control and real-time passenger information; - design of adapted stops, avoiding notched stops; - absence of traffic circles on routes, as this equipment designed for cars is inconvenient for both buses and cyclists, and even for heavy goods vehicles.

5.1.5.5. Fifth example: "flexible" public transportation

Conventional public transport operating on fixed routes with predefined schedules can be complemented in certain areas and during certain periods by more individualized solutions, such as on-demand minibuses, collective cabs, etc. While interesting as a complement to give some flexibility to the public transport network on the scale of an agglomeration and its periphery, these solutions cannot be generalized to the entire periurban area and cannot be a comprehensive response to serving areas where housing is increasingly diffuse (a problem that must be addressed by other measures such as the integration of urban planning and transport policies).

The overall efficiency of public transport provision at the level of an agglomeration and its periphery depends on the judicious combination of several systems, such as those mentioned in the previous five examples or others. As much of the conurbation as possible should be served by a meshed network of several efficient lines, which may be equipped with the same or different systems. It is therefore necessary to achieve a judicious intermodality between the lines of the main network, between the main network and feeder lines - or secondary lines, if the size of the agglomeration justifies a hierarchy - and with suburban or regional lines. To be fully effective, this intermodality must include at least five equally important levels of implementation:
- physical facilities to minimize platform-to-platform transfer distances and improve comfort;
- ergonomic physical signage; - several levels of passenger information before departure and during the trip in real-life situations, taking into account possible disruptions;
- synchronization of schedules below a certain frequency threshold; - ticketing allowing simple pricing of all modes used.

5.1.6. Improving the offer of non-motorized modes

We have seen that public transport is evolving and becoming increasingly diversified into a large number of families and sub-families adapted to different territorial configurations; for non-motorized modes, we find a comparable phenomenon, even if the complexity is less, and even if it is the organizational measures external to the mode that take on even greater importance here.

For walking, we will not insist too much on the evolution of the pedestrian's equipment (shoes, new luggage with ergonomic wheels, information devices, etc.), but we will notice that there are variants of walking that require special consideration. Depending on the times, age groups and fashion phenomena, this may involve rollerblades, skateboards, scooters or other equipment. In the context of the development of an alternative offer, these means of transport are not to be neglected. For example, people who are not attracted to intensive walking can make trips of a few kilometres by rollerblades, provided that specific traffic areas exist. For cyclists, technical improvements are likely to diversify the range of services on offer in order to adapt to a variety of needs for utilitarian trips in urban, suburban or rural areas (and not just leisure trips with mountain bikes, racing bikes or touring bicycles): for example, bicycles that are well suited to transporting luggage or shopping, ergonomic folding bicycles, bicycles adapted for attaching rain coverings, bicycles with electric assistance to facilitate hill climbing, etc.

The profiles of cyclists are very varied in terms of speed requirements (and maximum acceptable distance) or comfort equipment needs; only a transportation policy that largely favours this mode (or stops putting it at a disadvantage) could facilitate the emergence of a non-negligible market for variants adapted to particular cases, as is, proportionally speaking, currently the case with the automobile, which comes in an infinite variety of models. The electrically assisted bicycle often attracts attention because of its technological dimension (improvements are to be expected from new means of storage such as super-capacitors or new electric motors); it is indeed one means among others to meet the expectations of certain potential users, but it does not solve the essential problem: the need for moderation of car traffic (Héran, 1995). To promote the development of cycling, all links in the chain must be taken into consideration beyond the vehicle, and beyond the infrastructure: secure parking facilities, a wide range of equipment depending on the use (e.g. showers and changing rooms in the workplace), education/control of motorists, changes in regulations (which sometimes prohibit bicycles in building yards), intermodality with public transport. Overall, the latter is still relatively little used in France but, in the form of bicycle parks or instructions, it is widespread in a number of foreign countries such as Germany and Japan, not to mention the Netherlands.

In some urban areas, it is necessary for each type of non-motorized mode to have specific spaces to avoid problems of cohabitation, given the speed differentials and differences in trajectories. Thus, if rollerblading is to become an attractive mode without hindering pedestrians and cyclists, it would be necessary to have traffic spaces taken from the roadway currently dedicated to car traffic and not from sidewalks or bicycle paths. In other urban areas where roads are narrower and traffic is lighter, the coexistence of all modes is possible according to the "Zone 30" principle. In order to encourage walking, taking into account the needs of all categories of people (from people with reduced mobility with different types of disability to more sporty walkers seeking speed), various types of facilities and arrangements are necessary: a finer grid of pedestrian routes than the grid of roadways, adapted paths of sufficient width, inclined surfaces, ergonomic markings, mechanical aids such as elevators or hectometre transport, modern means of information on routes, etc. In order to reduce walking times, it is necessary to focus less on pedestrian safety and less on car traffic, especially at road crossings and junctions, which often impose detours on pedestrians or require them to wait too long (or even two-step crossings); these interfaces with road traffic show us the limits of a mode-by-mode reasoning and lead us to the more general reflections developed below.

5.1.7. Mobility and sustainable development

It follows from the above considerations that alternative modes of transport cannot be equally effective for all types of service in areas that have been shaped (and equipped with infrastructure and networks) according to the characteristics of the individual automobile. A range of measures is therefore necessary to ensure that these form the basis of the mobility system. If current trends are to be reversed - and not just slowed down the increase in car use - strong, diversified and coherent measures are needed. In this article, we do not deal with the socio-political feasibility of heavy decision making. We will only note that a first level of measures is in keeping with the times (technological improvements, urban travel plans, SRU measures, etc.), but that real decisions cannot be envisaged without giving greater importance to the criterion of sustainable development. Despite the implementation of specific projects that have received wide media coverage (a few streetcar lines, a few bicycle paths, etc.), the dominant trend is to allow the preponderance of the individual car to develop, expecting radical improvements in the environmental impact of the automobile product.

However, without underestimating the importance of the progress that is being made, the combination of increasing car use with a desire for increasingly powerful and comfortable vehicles risks making this progress insufficient in terms of energy consumption, the greenhouse effect, space consumption and the effects of cutbacks, the destruction of landscapes... without forgetting other aspects not yet resolved in the short or medium term (air and water pollution, noise...) and without forgetting road insecurity which is, in part, a direct consequence of the great attractiveness of the automobile, resulting in both high mileage and dangerous behaviour (speed, use of the telephone while driving).

5.1.8. Integrating urban planning and transportation policies

The integration of urban planning and transport policies (Wiel, 1998) is an essential element in developing sufficiently dense and mixed urban planning at the local level to facilitate the use of walking (and other nonmotorized transport modes), and in developing a structure for facilitating public transport use over a larger area. Current trends toward peri-urbanization are not necessarily incompatible with alternative mobility, provided that peri-urbanization is organized and structured to facilitate the use of public transport and cycling.

It is quite obvious that such integration would in principle be much easier to achieve if a new urbanization was to be designed from the outset over an entire virgin area. We will briefly refer to an example of an ideal model, that of the "hollow city" (Maupu, 2003): in contrast to the "car city", urbanization here takes place in a ring around a circular public transport line, all the more densely the closer one is to this line. In reality, we are more or less far from this model (cited for educational purposes), which means that the public transit network cannot be so simple, hence the use of intermodal systems between several systems, and that the built environment cannot always be arranged in an ideal manner. But, contrary to popular belief, even a moderately dense built-up area can potentially be efficiently served by public transport (including rail) and walking if the housing stock is organized and clustered. A very theoretical calculation shows that, within an 800m radius around a station, a continuous suburban area consisting of 400m² of land has a population of around 12,000 inhabitants, without taking into account the occasional existence of apartment buildings, which would tend to increase this figure or compensate for the land occupied by public facilities and shops. In reality, the suburban areas are not necessarily organized in such a continuous manner, but bus, minibus and bicycle transport can be provided.

One idea that has become fashionable is to promote intermodality between public transportation and the private car. There are two solutions: the practice of "kiss and ride", which can be encouraged by appropriate facilities, and the construction of park-and-ride facilities. Park and ride" policies offer a number of advantages and are preferable to the construction of new parking lots in city centres, but they cannot be generalized because of the large amount of space required in the vicinity of stations.

The location and size of park-and-ride facilities must therefore be studied, taking into account possible "perverse" effects:
- the realization of large parking lots near the stations can make the walking or cycling routes less attractive;
- Park-and-Ride lots can compete with feeder buses or minibuses; thus, rather than attracting motorists who would not have taken the heavy public transit route without the existence of the Park-and-Ride lot, one can also attract users who would have taken public transit anyway but would have chosen another mode of feeder service without the existence of the Park-and-Ride lot;
- Finally, park-and-ride areas in the vicinity of stations could be used to build apartment buildings or to implement activities that could generate increases in ridership on the transit line. In the current context, door-to-door trips made using alternative modes take longer than the same trips made by private car. There are several ways to reduce or eliminate this disadvantage:
- the improvement of the offer already mentioned; - the reduction of car speeds which, in addition to modal rebalancing, can be motivated by a whole series of other reasons (improvement of road safety, reduction of noise, reduction of energy consumption - and of the contribution to the greenhouse effect - reduction of air pollution, reduction of the insecurity or inconvenience suffered by pedestrians wishing to cross...); - the reduction of the speed of the car which, in addition to modal rebalancing, can be motivated by a whole series of other reasons (improvement of road safety, reduction of noise, reduction of energy consumption - and of the contribution to the greenhouse effect - reduction of air pollution, reduction of the insecurity or inconvenience suffered by pedestrians wishing to cross ;
- the development of services related to public transport and non-motorized modes (services of various kinds, including commercial services); the aim now is to save time, not by reducing travel time (which is only possible within certain limits), but by carrying out during travel time activities that would have been necessary after or before the trip in question (shopping, eating out, telephone calls, information gathering, listening to information, etc.).

Services have been developed extensively for the automobile, which contributes to increasing its attractiveness to the detriment of other modes, but also has negative effects (for example, telephoning while driving, even with a "hands-free" device, increases the risk of accidents (Pachiaudi, 2001). For public transport, services should be developed in vehicles, at stations or at interchange points in association with modern information media. For example, if a passenger, leaving his streetcar, metro or regional train to wait for a suburban bus, is informed in real time that the wait is x minutes, he can use this time to make purchases or other activities compatible with the announced duration. The commercial services aspect brings us back to the issue of urban planning policies already discussed. The implementation of an alternative to the private car also involves decisions to locate shopping centres, cinemas and other facilities, either in central areas or near public transit hubs, and not in areas that are easily accessible only by car thanks to vast parking lots.

5.1.9. Costs and prospects of a more efficient alternative offer

A significant development of alternative modes would certainly require particular attention to the economic aspects. We will mention only a few major trends here:
- the development of non-motorized modes is very inexpensive, both for the community and for users;
- The development of public transport is more expensive, but it can generate additional revenue to the extent that the quality of the service can attract more full fare users and to the extent that more sophisticated pricing schemes can be used to match the price to the service provided;
- In an alternative scenario, there would necessarily be a shift in spending from cars to alternative modes (less spending on new road infrastructure, less parking, less equipment, etc.);
- some guided public transport is costly in terms of investment, but this investment must be amortized over several decades; moreover, mechanisms could be put in place to recover the financial gains generated on the land and buildings in the areas served for the financing of guided transport; - bus-type public transport is expensive to operate, but its profitability can be improved both by reducing car traffic (better rotation of vehicles and drivers) and by a better occupancy rate;
- Several solutions exist to reduce public transport costs (standardization, scale effects, technological improvements, etc.).

In conclusion, an alternative mobility to the individual car is technically feasible, but in the current context it does not seem likely to spread significantly without a combination of improved supply and a set of measures, including parking policies, space allocation and speed regulation policies that restrict (or favour less) the car, to a greater or lesser extent depending on the nature of the territories and the evolution of urban planning policies. The question is whether such measures could be accepted thanks to the combination of an alternative offer that has become more efficient and an increased awareness of the sustainable development criterion. It would also be necessary to address issues that we have not addressed in this paper, such as the interfaces with freight and utility transport, as well as long-distance passenger transport, and social aspects, including the positive impact on the fraction of the population that does not have access to motorization (Faivre, 2003) or is unfit to drive safely.

5.2. Ile-de-France: the prospects for sustainable development

The evolution of the Ile-de-France transportation system is governed by various planning documents, of which we will only briefly recall here the general orientations. The Ile-de-France PDU[32] was adopted in 2001. Its main objective was, in accordance with the law on Air and the rational use of energy, to define measures to reduce road traffic in Ile-de-France. As a result of this objective, it rendered obsolete another planning document, the Ile-de-France Master Plan (*Schéma Directeur d'Ile-de-France*, SDRIF), adopted in 1994, which forecast traffic growth and planned the corresponding investments. The Ile-de-France PDU provided for a large number of measures to move towards this objective, but its flagship measure was the "Mobilien" program, which consisted of transforming 150 bus lines into lines with a greatly improved level of service (improvement in frequency and speed with partial exclusive right-of-way, passenger information on travel times, careful handling of connections with stations and subway stations, etc.). Appropriations in the regional budget for this measure alone total €150m. Some 40 lines in Paris and the inner suburbs have been transformed in this way, because the transformations required on the road network take a long time and require a great deal of consultation between the players involved. The PDU adopted in 2000 is currently being revised.

[32] PDU : Plan des Déplacements Urbains : Urban Travel Plan for Ile-de-France.

It was followed by a Paris Travel Plan (PDP) which is currently being implemented. The project for a new SDRIF was approved by the region on February 15, 2007. Its final adoption depends on consultation with the State, which expressed its disagreement with certain options in September 2007. This orientation document sets the priorities for the State-Region Plan Contracts (CPER), which program investments according to available resources. Below we examine the main options, successively at the Paris and regional levels.

5.2.1. Prospects in Ile-de-France

The policy conducted by the Paris City Council has been in line with the PDU's logic, amplifying it. The flagship measures of this policy have been the creation of very wide bus lanes allowing bicycles and buses to coexist, the drastic reduction of the free parking offer, and the development of the residential priority parking offer with an extremely attractive rate (€0,5/day, compared with €1 to €3€/h for parking at destination). In addition, the bicycle service has been considerably strengthened with the introduction of Vélib' [33], a system of nearly 20,600 self-service bicycles, and the marshals' streetcar has replaced an already heavily protected circular bus line on part of its section. It will be extended in the coming years and will eventually form a complete loop around Paris. This overall policy has resulted in a significant reduction in space for general traffic and parking at destination.

The results, in terms of the objectives pursued, are impressive: a 17% decrease in PV traffic in Paris (excluding the ring road), with a significant drop in speed. Bus use has developed less than expected, but many transfers have been made to the subway, several lines of which are now saturated, and to scooters and motorcycles, whose traffic has increased sharply. After the implementation of the *PDU* in 2001, we can see the evolution of the uses of modes in Paris between 2002 and 2007 in the table and the following figure. The growth in public transport use is very positive for the subway, low for buses, and PV use has decreased in Paris. On the other hand, the use of two-wheeled vehicles, including bicycles and motorized two-wheeled vehicles, is increasing, especially during 2006 and 2007. However, it remains at a fairly low overall level.

[33] There are 41 million trips after 18 months of operation.

	2012	2013	2014	2015	2016	2017
Motorcycle (2)	Annual evolution index of the number of 2-wheelers					
Bicycle	1,0 (1)	1,31	1,37	1,44	1,42	1,89
Motocycle	1,0 (1)	0,98	1,02	1,11	1,11	1,22
Motor vehicle	Annual traffic growth (vkm/h)					
Car (3)	8070	7864	7686	7509	7413	7353
	1,0 (1)	0,97	0,95	0,93	0,92	0,91
Public transportation	Number of trips made (in millions of trips made)					
Bus	356	346	352	335	330 (4)	363
	1,0 (1)	0,97	0,99	0,94	0,93	1,02
Subway	1283	1248	1336	1373	1410	1388
	1,0 (1)	0,97	1,04	1,07	1,1	1,08

Figure 5.2.1. Changes in transportation usage in Paris between 2012 and 2017

Source: Paris City Hall, 2017

Note: 1. 1 = reference value, annual average 2002

2. Established from counts carried out on a sample of 6 sites, every other Tuesday, during the hourly periods: 8:30-9:30 a.m. and 5:30-6:30 p.m.

3. Including traffic in Paris intramurals and on the ring road for working days between 7:00 am and 9:00 pm.

4. Commissioning of streetcar T3 (December 2006)

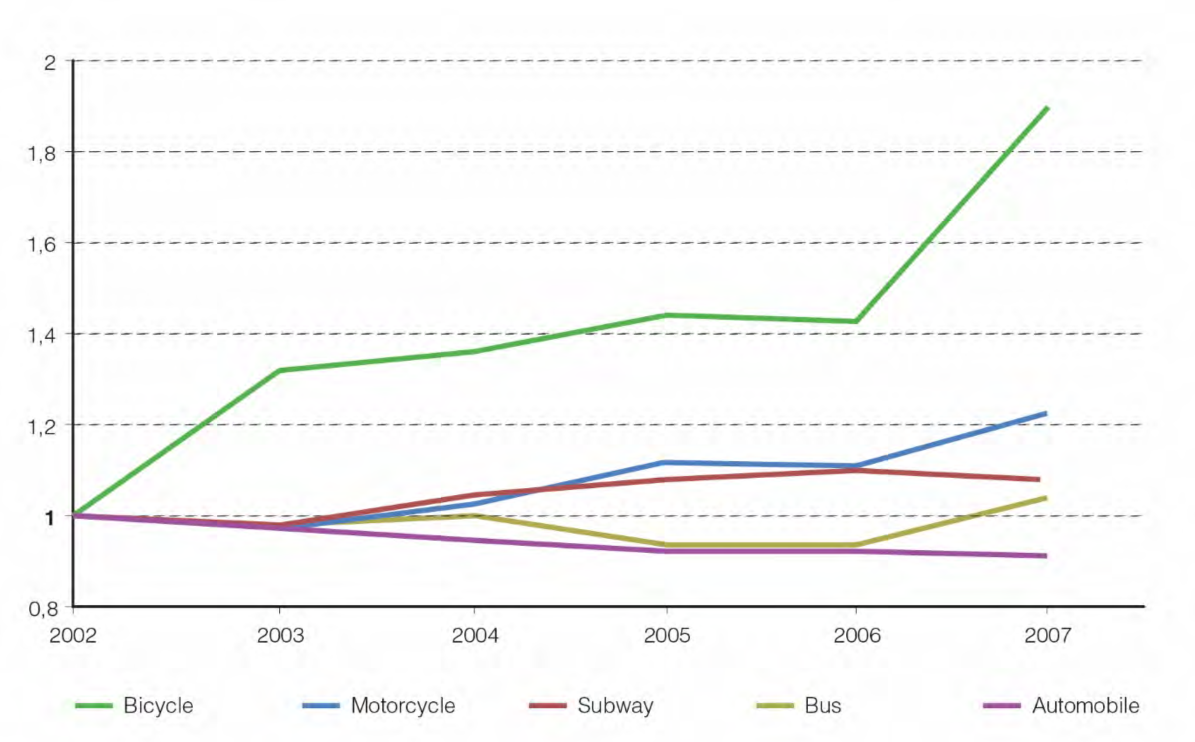

Figure 5.2.2. Evolution of mode usage in Paris based on the reference value in 2012

Source: Created by the author

The continuation of this policy is programmed by the Local Travel Plan adopted in 2007, which calls for a one-third reduction in PV traffic in Paris by 2020, offset by an increase in PT services, but which will also be accompanied by an increase in motorized two-wheeler traffic.

Challenges and responses related to development prospects by 2030 in IDF
(Paris travel plan project, Paris City Council, 2017)

<u>Issues</u>

A public health and sustainable development issue: improving air quality and reducing transport-related nuisances

- the Climate Plan aims to fight against global warming;
- the Noise Control Plan aims to reduce traffic-induced noise nuisance.

A social and societal challenge: improving mobility for all:

- by giving priority to public transportation, adapting it to family travel;
- by making the fare structure fairer, but also guaranteeing equal access to travel for people with disabilities.

An urban challenge: enhancing, modernizing, beautifying and better sharing public space:

- it is essential to establish the principles of a rebalanced sharing of public space between the different users, so that everyone can move around in a city that is more pleasant to live in;
- the rules of cohabitation in the urban space but also behaviours must change to give way to peaceful behaviour, with greater respect for the most vulnerable.

An economic challenge: to encourage the economic vitality of Paris and the metropolitan area:

- the vitality of certain major sectors of the Parisian economy, such as trade and tourism, is linked to the quality of the transportation services offered in Paris and its metropolitan area;
- the challenge of transporting goods, which is essential to the economic, social and domestic life of Paris, remains to be built at the level of the agglomeration.

A regional challenge: strengthening regional solidarity at the scale of the dense zone and the region:

- Paris Region local authorities have to work together to meet major challenges in terms of equity, the right to mobility for all, and the fight against pollution and urban landscape degradation. In this respect, Parisians have become very aware of the need to give priority to suburb-to-suburb and Paris-to-suburb travel, which is still abnormally poorly served.

Answers

Continue the process that has begun to change travel habits. Motorized vehicle traffic has fallen sharply, without any noticeable deterioration in average speeds. This decline in traffic was accompanied by a significant increase in public transportation ridership during the same period (2001-2005). In terms of greenhouse gases, the overall change in carbon dioxide emissions in 2007 compared with 2002 is expected to be 9% lower. Unlike nitrogen oxides, this decrease is exclusively related to road improvements and the decline in traffic in Paris.

Actions to be articulated in time and space.
The major thrust of the Paris travel policy is to improve mobility for all in a sustainable development perspective.
-give priority to the development of new transportation alternatives to the car; - facilitate the mobility of priority players; - integrate Parisian policy into a shared vision of the metropolitan area. For this matter, it is necessary to strengthen the coherence and perspective of our policy, in time and space.

This strategy can be broken down into five main types of action, described in the following sections:

- developing alternatives to individual motorized travel;
- reduce motorized traffic;
- facilitate economic travel; - promote residential parking; - share and beautify public spaces.
- targets in figures
- quantified objectives for the movement of people;
- quantified objectives in terms of the environment and public health;
- targets for commodities; See the following table for detailed numerical targets.

Quantified objectives for the movement of people		
1.	In terms of travel practices	
	in 2023	All of the PDP's actions are aimed at enabling users to make greater use of sustainable travel practices. Thus, the first objective is to increase the share of public transport, taxis, cycling and walking (75% in 2001) to reach 80% of passenger trips in Paris. (1)
	in 2030	Towards the target of 83% of passenger trips involving Paris, compared with 75% in 2001.
2.	In terms of public transport supply	
	in 2023	20% increase in the travel offer on the PT networks of interest to Paris, from a capacity of 9.6 million trips in 2001 to 11.5 million trips in 2023.
	in 2030	30% increase in the number of trips on the PT networks in Paris, representing 12.4 million trips in 2030.
3.	In terms of personal vehicle traffic	
	in 2023	26% decrease in measured network traffic compared to 2001.
	in 2030	40% decrease in measured network traffic compared to 2001.
4.	In terms of access to the city for all	
	in 2023	The mobility of persons reporting a disability in the GSS will have increased by 15% over the 2001 GSS.
	in 2030	The mobility of persons reporting a disability in the GSS will have increased by 25% over the 2001 GSS.
Quantified objectives in terms of the environment and public health		
1.	Air quality	
	in 2023	Nitrogen dioxide concentrations measured near traffic will be below the threshold of 40 µg/m3 for 50% of Parisian streets within the city walls.
	in 2030	Nitrogen dioxide concentrations measured in the vicinity of traffic will be below the thresholds set by the European Union for 100% of Parisian intramural streets.
2.	Greenhouse gases	
	in 2023	25% reduction in CO_2 emissions from traffic in Paris.
	in 2030	60% reduction in CO_2 emissions from traffic in Paris.
3.	Traffic noise	
	in 2023	65% of the Parisian lanes will be below class 5 of the acoustic classification.
	in 2030	80% of the Parisian lanes will be passed below class 5 of the acoustic classification.
4.	Travel safety	
	in 2023	A 55% drop in traffic fatalities and a 65% drop in fatalities in Paris.
	in 2030	A 70% drop in traffic fatalities and an 80% drop in fatalities in Paris.
Targets for goods		
	in 2023	60% increase in the tonnage of goods entering Paris by rail; 40% increase in the tonnage of goods entering by water.
		Harmonization of delivery regulations between Paris and neighbouring municipalities.
	in 2030	110% increase in the tonnage of goods entering Paris by rail; 75% increase in the tonnage of goods entering by water.

Figure 5.2.3. Quantified objectives for the outlook in 2023 and 2030 in Ile-de-France

Source: Draft Paris travel plan, Paris City Council, 2017

Note: 1. According to the nomenclature, “trips involving Paris” refers to trips with their origin and/or destination in Paris, i.e. all trips between Paris and Paris and between Paris and the suburbs.

5.2.2. Prospects for Ile-de-France-wide projects: the SDRIF

The new Ile-de-France master plan, which replaces the 1994 plan, is based on 3 political priorities: promoting social and territorial equality and improving social cohesion; anticipating and responding to major changes or crises, particularly those linked to global warming and the rise in the price of fossil fuels; and maintaining Ile-de-France's global influence. These objectives are reflected in ambitious targets for housing construction, particularly social housing, with a strong priority in the heart of the urban area, which makes it necessary to optimize and intensify land use. In transportation, most of the projects involve the development of PT (but also bicycles) with a general focus on “developing reasoned mobility for people”.

The means are the creation of a network of ring road structural lines, the construction of tangential rail lines and the development of clean sites on roads, as well as numerous subway extensions. The development prospects for transportation in Ile-de-France, as drawn up by the SDRIF, are extremely clear-cut. Road investments are extremely limited, and several projects planned by the State (which plays a role in Ile-de-France for national roads and highways) are ruled out, such as the western loop of Ile-de-France and the extension of the A12. On the other hand, the list of public transport projects for 2020 is impressive: major rail ring road projects (Arc express in the middle ring, rail tangential in the outer ring, to which can be added 14 subway extension projects, 4 RER extension projects, 7 UPT/ERW projects decided on using streetcar technology, 27 other UPT/ERW projects whose technology has not yet been chosen.

All of the projects mentioned represent a very significant investment, especially since they are superimposed on investments to modernize certain existing subway and RER lines, investments to improve the accessibility of services for the disabled, and major investments in rolling stock. This is one of the reasons for the State's reservations expressed in the September 2007 notice. Referring to the State-Region Plan Contracts, which are the mechanisms for programming and effectively financing projects[34], he noted that "the cost of the projects (€35b in total) implies investments more than twice as much as the €4b committed by public authorities in the 2000-2006 State-Region Contract in Phase I (2007-2013) and more than three times as much in Phase II (2014-2020[35]. This is why the region adopted an initial negotiating position in March 2009 with a "mobilization plan for transportation" reduced to €18,6b, including €7,3b for emergencies (making line 13 accessible for the disabled, orders for rolling stock to desaturate line 13 and extension of line 14), €6,3b for projects to be accelerated, including 7 new streetcars and a tangential rail line, and €5b for major projects (arc express and western extension of line E).

The State's reserve was based not only on the total cost of the projects, but also on their dispersed nature and their more local than regional character. That is why it is not entirely surprising that in 2009 the State proposed another vision, based on a priority investment of regional scope, the "roller coaster". An investment envelope of €35b is put forward, €21b of which should be devoted to the "roller coaster".

The 130-kilometre-long roller coaster will be fully automated, and is expected to operate day and night at 80km/h and be connected to major subway stations. In addition, the State will support the continuation of certain projects in the region: extension of subway lines, including line 14 (north to Roissy via Pleyel-Le Bourget and south to Villejuif-Rungis and Orly) to relieve congestion on line 13.

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[34] They have contributed and continue to contribute to the construction of heavy transport lines and streetcars, as well as to the improvement of transport hubs with a view to intermodality.

[35] State Notice on the SDRIF Project, September 2007

5.2.3. The interest and limits of these projects

Although it is difficult today to say what the future holds for the various projects reviewed, it is clear that the SDRIF orientations, like those of the PDU, are in resonance with many planning exercises in other European cities. The desire to reduce PV traffic (which has led to the introduction of tolls in Norwegian cities, London and Stockholm, heavy subway investments in Madrid, and severe restrictions on PV traffic in many Italian cities), the desire to give PT a greater role, and the desire to give bicycles a greater role, as is happening in the Netherlands, Denmark and Germany, are everywhere present.

Ile-de-France documents have become much more attentive to inter-city connections compared to the comparable exercises of the 1980s, which led to the creation of Eole and Météor, which became Line 14. They are guided by a twofold concern: on the one hand, space savings, which are all the more important as the SDRIF wishes to redensify the central zone, and on the other hand, control of fuel consumption and local pollutant emissions (particularly marked in the Paris Travel Plan).

From these points of view, they can be considered to be guided by a sustainable development perspective. On the other hand, they also have in common themes that are not, or very marginally, addressed:
- the consequences in terms of travel time for users of the selected options, and the analysis of spontaneous adapts of users to increasing traffic difficulties. This is particularly true for the Paris MDP, where significant social losses are linked to the first part of the Parisian policy and a very significant and positive contribution from this mode (15 to 19% of motorized vehicle traffic in Paris, depending on the time of day, with a peak in the evening rush hour). Also, there is a potential contribution of light, compact and electric vehicles that is several orders of magnitude greater than the current use of two-wheeler (Prud'homme et al., 2006; Massot et al., 2009).
- the consequences in terms of public transport financing needs. The figures proposed above relate only to investment, and it already seems difficult to finance all projects. As our calculations have shown (part two), those that are carried out will generate financing needs for operation, because the resources from users are today far from covering operating costs alone. Here again, contrasting prospective scenarios show the importance of questions relating to contractualization, operation and pricing modes in order to move towards a financially sustainable development of the public transport offer (Orfeuil, 2005; Faivre d'Arcier, 2008). In the conclusion of its report, Faivre d'Arcier proposes to "link financing and performance for sustainable urban mobility" and emphasizes that, in the major provincial cities, it is now recognized that it is not enough to increase vkm to gain customers and, above all, improve the financial balance of the networks. Investment choices must be more reasoned, both in terms of investment costs and the attractiveness of the new offer, as well as in terms of additional operating costs. ". Finally, international comparative exercises (European Maretope project in 1998) show very significant differences in the coverage of costs by revenues, ranging from 30% to 80% depending on the European country.

For this reason, following the review of Yokohama planning documents, the next section of this paper will examine some policy options based on our cost analyses, which are based on renewed approaches to parking pricing on the one hand, and on a broader range of transit fares on the other, both of which incorporate the possible roles of two-wheelers.

5.3. Lessons to learn for more sustainable mobility

Ile-de-France, like other major cities in Europe and around the world, wants to be part of a sustainable development perspective. Even if the "official" definition of sustainability explicitly refers to the economic, social and environmental dimensions of development, its use in the field of public policies implicitly refers to an increased, even greatly increased, consideration of the environmental dimension.

The cost analyses carried out on the overall scale of the regional territory reveal the relatively debatable nature of this perspective: the so-called "external" costs represent only a fairly small share of total costs overall, and any overall action on the system that would be motivated by minimizing these costs alone could potentially increase other cost items by a level substantially greater than the savings produced in the environmental field.

Disaggregating costs by type of territory provides an additional element. It reveals a very high variability of costs according to the area where traffic occurs, with very high environmental costs in the densest central part of the conurbation, and much lower costs in the large, sparsely populated peripheral areas. The exercise carried out is certainly debatable. It assumes numerous hypotheses, some of which may be disputed, but it cannot be denied that an area with such great contrasts as Ile-de-France (in terms of population densities, for example, with significantly greater variations than in London, for example, and in terms of the functionalities of the territories, with, for example, the territory of the city of Paris increasingly devoted to leisure and tourism) cannot but suffer from highly differentiated traffic problems. The exercise must therefore build solutions that are themselves differentiated by type of territory.

Calculations of congestion costs and space consumption are appended in the environmental reasoning, which is mainly concerned with nuisances and the greenhouse effect. Their status as an externality is poorly defined because they are in fact borne for the most part by motorists in the form of lost time. Calculations show that these dimensions are potentially very important, in a large part of the region for congestion, in the central area and in a few peripheral points for parking. It should be added that the issue of congestion in public transport, which is not addressed here for lack of literature studies, is nevertheless strongly present in the public's appreciation of public transport and in the media treatment of public transport.

Finally, the question of the cost of road insecurity deserves specific consideration. In the administrative tradition, in France or elsewhere, road insecurity is dealt with by a specific administration, with a specific logic and specific objectives, largely independently of the urban mobility management cultures tended by the problem of the modal shift from PV to public transport and of environmental cultures. This is evidenced, for example, by the low priority given to these issues in urban travel plans (PDUs). Our assessments, which are consistent with other evaluations in the literature, suggest, however, that insecurity, despite the progress made, continues to play a significant role in the overall "external costs" of mobility. They also show that the perception of safety plays a fundamental role in the modal choice itself. Indeed, the low use of two-wheeled modes, short-distance bicycles and motorized two-wheeled vehicles for medium distances, contrasts with their excellent performance in terms of travel time (compared with PV and public transport) and cost to the user (compared with car).

In this section, based on our cost analyses in Ile-de-France and a comparison with the transportation situation in Yokohama, we propose to identify a small number of strategic directions for more sustainable mobility in both areas. These prospects will be addressed with a view to combining the economic, social and environmental dimensions. We also need to integrate the public authorities' ability to act. This capacity lies partly in the field of their ability to mobilize public opinion, as shown by the "Grenelle", and for which we will not be able to report, but also in their ability to release resources for systems that have a structural need for public money, particularly PT.

From this multidimensional perspective, three types of cost will be favoured: external costs, as a reflection of environmental concern, costs for users, as a reflection of economic and social concern, and the financial summation for public authorities, as a reflection of their capacity to act and a certain equity between users.

First, we need to go back over the status of the cost analyses.

5.3.1. The costs of the modes: what status?

In Part II, we have focused on assessing as realistically and accurately as possible the costs per pkm of mode use for individuals, communities and the environment. The scale of the effort required should not obscure the fact that the results of these estimates are partly based on permanent and structural factors and partly on contextual factors that any mobility policy is likely to change. The cost estimates therefore strictly speaking reflect the average costs in the state of the system in 2003.

Some elements have a permanent and structural character. The cost of owning a bicycle should remain lower than that of a car, its rolling speed should remain lower in most areas, its parking space should be more limited than that of a car, and its range should remain smaller than that of motorized vehicles. The overall cost of a bus or taxi service is fundamentally determined by the size of labour costs, which are likely to change only fairly slowly, whatever reforms may be envisaged. Two-wheeled vehicles, a priori offering less protection to their occupants, are likely to remain less safe in terms of secondary safety than four-wheeled vehicles. Differences in costs related to noise or pollution between territories will remain linked to the number of people exposed, and this number will remain higher in Paris and the inner suburbs than in the outer suburbs.

Other elements contributing to cost estimates are much more contextual in nature. This is the case, for example, of the environmental costs of the automobile, which have declined sharply with technological progress and will continue to do so. This is the case for parking costs and their consequences. High fares are moderating the trend toward motorization, directing demand toward two-wheelers, PT and even taxis, helping to moderate congestion costs. This is also the case for the cost per pkm in public transport, if appropriate policies ensure better ridership in today's lightly loaded hours. This is the case for on-street parking, with a fare payment rate of less than 30% in France, due to poor monitoring and the cost of fines[36]. Finally, this is the case for two-wheeled vehicles, which a proactive road safety policy could lead to more satisfactory primary safety levels.

[36] The fixed fine is €11 in France as in Paris. It is £130 (€145) in London.

Country	Germany	Austria	Denmark	France
Motorcycle risk/car risk	8,3	9	9,4	17,2

Figure 5.3.1. Relative risk of fatal accidents per billion km travelled between motorcycle and PV (car = 1)

Source: Estimation of the author based on road safety source tables, 2015

This highly contextual nature also applies to the distribution of different types of cost within a means of travel. A tolling policy tends to reduce time costs and increase monetary costs. Unicity of fares in public transport (e.g. the same ticket for an internal journey in Paris, whether by bus, subway or RER) directs the majority of users towards the fastest modes and contributes to a higher occupancy of rail modes than buses.

Finally, other elements can be relatively misleading, linked to selection effects. This is the case for the estimation of the temporal costs of using public transport in the inner suburbs. While public transport in Paris provides a relatively homogeneous service, this is not the case in the inner suburbs. In the inner suburbs, the bulk of public transport users are those who can benefit from a public transport service that is relatively time-competitive in relation to the car, a service that has been introduced because potential demand has been judged sufficient. On the other hand, the bulk of non-public transport users do not have such a service, so that the potential alternative in existing public transport would be much more time-consuming for them, if not impossible because of the lack of service, and the introduction of new services would be very costly to the community. The average observed time cost cannot be taken as an indicator of a potential time cost associated with a hypothetical modal shift.

We will therefore bear in mind for the analyses that follow this dual structural/contextual dimension of costs, which refers both to the usual differences between average and marginal costs, and to differences related to institutional contexts, whether in terms of traffic and parking rules, taxation or technology penetration. Nevertheless, it is possible to situate the modes of transport in relation to each other in qualitative terms, and this is the subject of the table below.

	Cost per pkm			
Mode	**Monetary for user mode**	**Temporal for user**	**For public finances**	**External**
Bicycle	Low	High, except short trips	Low if owned, high if rented	Low
Motorcycle	Low to medium	Very low	Low	High
Automobile	High	Low to medium	Low in the absence of heavy investments	High
Bus Paris	Medium	High	High	Low
Bus suburbs	Medium	High	High	Low
Subway	Low	Low	Medium	Low
RER	Very low	Low if close to station	Medium to high	Low
Taxi	Very high	Low	Low	Medium

Figure 5.3.2. Situation in Ile-de-France related to the modes located on the cost scales

Source: Created by the author

Moreover, the question of costs cannot be a single criterion in a perspective of development or restructuring of demand. It is also necessary to integrate the development capacities of the modes, to which we devote the following paragraph.

5.3.2. Modes: what development potential?

This question is approached first in global terms on the regional territory, then by distinguishing the main types of link.

5.3.2.1. Global potentials

The ability of the modes to satisfy new customers, either as a result of increased mobility or by shifting from one mode to another, depends on four main factors.

- The capacity of the infrastructure used by the modes. Given our logic, which is not centered on a particular project, and the Ile-de-France context, where new roads are unlikely due to the ideological context and where rail investments will be limited due to financial constraints, we will reason below with constant infrastructure.

- Occupancy of the vehicles circulating on the infrastructures. It has long been known that PV in the city are under-occupied (1.3 persons/car on weekdays, and around 1.8 if weekends are included), but it is less well known that this under-occupation affects public transport at least as much, when measured over the whole day, and not just at peak times. The table below has been constructed by relating the pkm achieved to the place-km offered on public transport. Its results contrast sharply with the justified feeling that peak travellers may have. It can be seen that a strategy aimed at better vehicle occupancy at constant means makes sense. Furthermore, it can be hypothesized that, unlike rail, buses are in a position to develop their capacity rapidly and at low cost (switch to articulated services, frequency reinforcements, new lines).

SNCF	RER	Subway	Streetcar	TVM (1)	Bus Paris	Sub. bus	Optile Bus
12,50%	24,50%	26,60%	40,00%	46%	27,70%	25,80%	15,40%

Figure 5.3.3. Year-over-year average occupancy rate of public transportation vehicles

Source: STIF, 2015

Note: 1. Trans Val de Marne

Modes must be in a position to satisfy the demand. The following figure is taken from (Massot and Orfeuil, 2008). These authors analysed all trips out of the home by PV (sequence of trips from one trip out of the home to the return trip) of adult respondents with a licence to the global transport survey. They propose an estimate of the number of these outings that would be achievable by lighter modes (bicycle, electrically assisted bicycle, scooter), based on hypotheses (age of the person, distance to be covered, number of people involved in the trip). On the basis of their assumptions, the bicycle and electric bicycle could replace PV for 20-30% of trips, but only 5-10% of the kilometres, while the scooter would be able to replace PV for 60% of trips and 30% of kilometres. These modes cannot therefore do everything, but they are in a position to multiply their role by factors of 2 to 10, depending on the contexts that will be offered to their potential users. The advantage would obviously be to couple environmental gains (especially if scooters are electric) with gains in traffic and parking decongestion[37], in a context where road infrastructure will no longer grow, at least in Paris and the inner suburbs. There are undoubtedly several constraints that need to be removed to stimulate the use of these modes, but there is little doubt that improved safety in use is a necessary, if not sufficient, condition.

[37] We can also think of monetary gains for users. However, in this regard, the authors note that these gains need to be considered in aggregate, including the costs of vehicle equipment, maintenance, and insurance. Overall, the gains are significant if a car can be removed. Otherwise (e.g., equipping an additional vehicle), they are only effective in the current situation of low parking costs if the two-wheeled vehicle can be used with some intensity, which must be assessed on a case-by-case basis.

	Bicycle	Elec. bicycle	Moped	Automobile
Filters				
Age (years)	< 65	< 70	< 70	-
Maximum distance of the exit (km)	8	12	24	999
Accompaniment (maximum people)	1	1	1 or 2	-
Loop results				
Number of loops (effective)	747 550 21,3%	1 059 250 30,1%	2 175 936 61,9%	3 515 989 100%
Number of loops (Paris, PC)	322 140 22,6%	468 688 32,9%	932 425 65,5%	1 423 778 100%
Number of loops (GC)	425 410 20,3%	590 562 28,2%	1 243 510 59,4%	2 092 212 100%
Individuals results				
Number of loops (effective)	610 585 24,2%	859 418 34,1%	1 599 083 63,5%	2 518 712 100%
Number of loops (Paris, PC)	270 826 25,5%	392 960 37,1%	715 735 67,5%	1 060 045 100%
Number of loops (GC)	339 759 23,3%	466 458 32,0%	883 348 60,5%	1 458 667 100%
Kilometers results				
Total Ile-de-France (millions)	2,9 4,9%	5,6 9,4%	18,3 30,8%	59,4 100%
Total (Paris, PC) (millions)	1,3 6,3%	2,6 12,4%	8,0 38,4%	20,8 100%
Total (GC) (millions)	1,6 4,1%	3,0 7,8%	10,3 26,7%	38,6 100%

Figure 5.3.4. Technical transfer potentials, apprehended at the level of outputs of household

Source: Massot and Orfeuil, 2008

Lecture: "Loop results": 61.9% of the loops currently performed in internal combustion vehicles meet the criteria defined by the thermal scooter, i.e. can theoretically be performed with this alternative mode.
"Individual results": 63.5% of the individuals currently performing loops with thermal PV as their main mode are affected by this deferral (for at least one of their daily loops).
"Results km": 30.8% of the kilometres done in a thermal PV are theoretically "replaceable" by the scooter.
Note: as a reminder, the total distance travelled daily by all residents of Ile-de-France in a chauffeured PV is 82 million km.

Finally, people must be ready to change their habits, and there must not be too great a "psychological distance" between individuals and potentially usable means. This is fundamental for the use of two wheels, but it can also be important for public transport. For example, it can be observed that the rate of public transport pass holders falls from 48% in inner Paris to 32% in the inner suburbs and 23% in the outer suburbs. In the absence of a season ticket, the reflex to carry tickets is useful when using buses, for example.

Overall, figure 5.3.5 summarizes the development capacity of the modes, the main orientations that would allow their development and the interest of their development.

	Capacity to develop the offer and improve the service	Demand development capacity with unchanged infrastructure	Development niche	Interest
Bicycle	Meaningful (public shelters for night bicycle parking, for example)	High	All short trips Dense area and drop-off at stations	Urban Low cost Low space requirements, but marginal structural use (limited scope)
Motorcycle	Conditional: reliability of electric two-wheelers, safety investments (training, infrastructure, etc.).	High	All short and medium distances, all zones Station feeder	Saving in time, money, car, public costs / PT Urbanity if changes in vehicles and pipes
Automobile	Strong improvement in parking service possible Low additional traffic capacity in Paris /PC	Low in Paris / PC, significant in GC	Indispensable for long bypass trips, for trips of 3 and more, for load transport	Dominant mode at any horizon in terms of distance travelled
Bus Paris	Average	Notable off-peak	Off-peak, peak when metro / RER saturated Controlled public costs if off-peak	Urbanity, accessibility and low space consumption Limited by structurally low speed
Suburban bus	High	Important off-peak	Off-peak, peak if additional services are warranted	Urbanity accessibility and low space consumption Important in suburban areas without subway, speed can be improved
Subway	Low to medium (automatic metro)	Important off-peak	Off-peak	Urbanity and low space consumption First mode in Paris
RER	Low	Very important off-peak	Off-peak	Urbanity and low space consumption First mode for GC-Paris links
Taxi	High	Significant, if pressure on the car	Dense zone Substitute PTs for low-demand zones / schedules	Complement for families without a car No consumption of parking space Marginal use

Figure 5.3.5. Mode development capabilities

Source: Created by the author

5.3.2.2. Development capabilities by type of link

The capacity for substitution between modes (replacement of one mode by another) and complementarity (combined use of two successive modes) strongly depends on the characteristics of the trips, in particular their length, the type of link, the performance in terms of required duration, etc. 2001 for persons in a position to use a PV as a driver: persons over 18 years of age, licensed, with at least one PV in the household. The first gives the distribution of PV trips by distance and their geographical structure. The second assesses the state of competition between modes on the basis of the speeds of the modes on the links, and the third on the basis of the modal split observed in 2001. This paper will not provide an exhaustive analysis of this information, but will focus on the essentials.

5.3.2.3. Short trips

5.5 million PV trips, or more than half of all PV trips, are less than 4 kilometres in range. The bulk of these trips (except those involving several people, the very elderly, or those involving large loads) could be made in a lighter, less cumbersome mode (on foot, bicycle, moped, or scooter). The first regulating factor here is parking. In some cases, where services are frequent (in Paris and the dense inner suburbs), buses can provide an attractive service. However, in the current context, the monetary cost may be higher than the cost of PV (because paid parking is far from being the rule). In addition, occasional users do not have a pass and do not always have a booklet of tickets on hand.

However, just over 3 million of these journeys take place within the inner ring road, where parking constraints are likely to remain structurally low, with the exception of a few areas, and where the speed allowed by PV is high, which limits transfer possibilities. Finally, it goes without saying that the successive use of several modes of transport is inappropriate for this niche.

5.3.2.4. Travelling more than 4km to Paris

This is the niche where the competition between the car, public transport and motorized two-wheelers is the most open, but it is not the niche where PV travel is the most numerous. Between the inner suburbs and Paris (573,000 PV journeys over 4km), the number of PV and public transport journeys is practically equal, and the speed differences between PV and public transport are not very great on average. Motorized two-wheelers are far behind, despite their supremacy over these two modes in terms of speed. Better regulated and more expensive parking would be justified in this niche, and would produce transfers to public transport and motorized two-wheelers, with a notable role for two-wheelers for journeys of less than 12km, the most numerous, and probably combined two-wheel or PV & PT solutions for the longest ones. The new clientele arriving on public transport would make it easier to justify reserving bus lanes and some subway extensions. Between the inner suburbs and Paris, there are still 277,000 daily trips by PV.

When these trips do not belong to complex chains, an individual vehicle/train intermodality (or even coach, as in a car/coach intermodality experiment on the A10 freeway) is conceivable. It will also be encouraged by a more active parking policy in Paris, at least for residents of the inner suburbs travelling to Paris. In the opposite direction (Parisians going to the outer suburbs in smaller numbers), there is no obvious new incentive. In this niche, motorized two-wheelers no longer have a speed advantage and probably have structural disadvantages in terms of comfort and safety. This is indeed the area of predilection for interchange hubs.

5.3.2.5. Travel of more than 4km not touching Paris

They are very numerous (3.8 million, including 1.4 million at more than 12km) and the role of PT today in meeting this demand is small, except for exchanges between the inner and outer suburbs, which are rather radial and can benefit from services to Paris. Active management of parking in the inner suburbs can no doubt direct some motorists to public transport or two-wheelers for trips of less than 12km. The potential role of interchange hubs is probably quite small. It could solve some of the problems that cause travel, but would leave the question of destinations, which are not necessarily in the vicinity of stations in the inner ring, unanswered. On the other hand, given the pressure of traffic in the inner ring road on ring road routes, new investments such as Arc express or subway can be justified if they are on routes with a sufficient level of clientele. A precursory investment, the TVM, made in exclusive right-of-way buses, has been a great success.

Travel		**Total automobile**
Paris<>Paris	from 0 to 1,999km	211603 (2,1%)
Paris<>Paris	from 2 to 3,999km	184771 (1,8%)
Paris<>Paris	4km and more	143689 (1,4%)
Paris<>PC	from 0 to 3,999km	169301 (1,6%)
Paris<>PC	from 4 to 7,999km	269749 (2,6%)
Paris<>PC	from 8 to 11,999km	172632 (1,7%)
Paris<>PC	12km and more	130446 (1,3%)
PC<>PC	from 0 to 1,999km	1162228 (11,3%)
PC<>PC	from 2 to 3,999km	616745 (6,0%)
PC<>PC	from 4 to 7,999km	441638 (4,3%)
PC<>PC	from 8 to 11,999km	183154 (1,8%)
PC<>PC	12km and more	159797 (1,6%)
PC<>GC	from 0 to 3,999km	137694 (1,3%)
PC<>GC	from 4 to 7,999km	226935 (2,2%)
PC<>GC	from 8 to 11,999km	184084 (1,8%)
PC<>GC	12km and more	548353 (5,3%)
GC<>GC	from 0 to 1,999km	1998755 (19,4%)
GC<>GC	from 2 to 3,999km	1016858 (9,9%)
GC<>GC	from 4 to 7,999km	908741 (8,8%)
GC<>GC	from 8 to 11,999km	463159 (4,5%)
GC<>GC	12km and more	694241 (6,7%)
GC<>Paris	All distances	276790 (2,7%)
Total IdF		**10 301 363 (100%)**

Figure 5.3.6. Travel by car: geographical structure

Source: EGT, 2011

	Total	Car	PT	MAP and bicycle	Moto.	Other
Breakdown (%)						
Paris<>Paris	100%	13,20%	23,40%	51,40%	1,60%	0,60%
PC<>PC	100%	39,20%	7,70%	30,50%	1,20%	0,10%
GC<>GC	100%	48,70%	2,50%	18,90%	0,70%	0,10%
Paris<>PC	100%	36,00%	45,50%	2,50%	2,60%	0,70%
Paris<>GC	100%	25,30%	61,30%	0,20%	2,00%	0,00%
PC<>GC	100%	61,20%	17,20%	1,50%	2,30%	0,20%
Excluding IdF	100%	41,80%	7,70%	1,80%	0,40%	5,40%
Total	100%	40,20%	14,50%	22,40%	1,30%	0,20%
Distance (km)						
Paris<>Paris	1,84	3	3,49	0,54	3,03	3,5
PC<>PC	3,16	4,48	7,95	0,54	7,3	3,84
GC<>GC	4,92	6,39	11,23	0,65	6,77	6,01
Paris<>PC	8,21	7,71	9,14	2,34	9,21	7,43
Paris<>GC	24,62	22,12	25,26	19,15	23,33	57,78
PC<>GC	15,9	15,32	21,44	4,53	15,59	16,98
Excluding IdF	-	-	-	-	-	-
Total	6,14	7,44	12,1	0,62	9,18	6,62
Speed (km/h)						
Paris<>Paris	5,8	7,4	6,6	2,8	10,4	7,3
PC<>PC	10,2	12,6	10,6	2,8	19,9	8
GC<>GC	17,6	20,7	14	3,3	19	18
Paris<>PC	11,9	12,8	11,3	5,2	21	14,4
Paris<>GC	23	24,9	21,6	19,2	35,9	46,2
PC<>GC	22,1	23,2	18,3	11,3	30	34,7
Excluding IdF	-	-	-	-	-	-
Total	15,2	18,1	14,4	3,2	22,5	13,1

Figure 5.3.7. Modal split, average distance and speed by link type

Source: EGT, 2011

Note: PV driver alone in his car; 2WD: motorcycle; Other: other mechanized and taxi.

These observations provide a summary table of the advantages/disadvantages of different modal substitutions. These elements highlight a wide variety of situations.

	Monetary cost to the user	Time cost to the user	Cost to public finances	Social costs	Urbanity	Remarks
Automobile to PT	Beneficial	Small differences on routes to Paris. Very negative on the bypass, except for heavy new investment	- in the central zone -- except during off-peak hours	Improvement +++ in Paris ++ in PC + in GC	Improvement	
Automobile to bus	- in marginal cost, + in average cost today	Increase	Increase, unless off-peak	Improvement +++ in Paris ++ in PC + in GC	Improvement	Competition reduced to middle distances
Automobile to subway	Beneficial	Small difference in Paris	Increase unless off-peak	+++ in Paris ++ in the suburbs	Improvement	Reduced competition in downtown
Automobile to RER	Very beneficial	Low difference if close to station	--	++	Improvement	Competition especially in connections with Paris
Automobile to motorcycle	Beneficial	Beneficial ++ in Paris + in PC 0 in GC	Neutral	-- (security)	Improvement ++ in Paris (space consumption) + in PC + in GC in exchange hubs	Competition centered on middle distances
Automobile to bicycle	Very beneficial	Improvement (short distances in dense areas) Degradation otherwise	Neutral	Improvement +++ in Paris ++ in PC + in GC	Improvement +++ in Paris	Competition centered on short distances
Subway to bus	-	-	-	-	-	However, transfers can be interesting at peak
Automobile to taxi + car sharing	Beneficial for people with low automobile mobility	Depends on location	Neutral	Improvement (space consumption)	--	Competition possible where PT is very good

Figure 5.3.8. Advantages and disadvantages of modes in a potential transfer perspective

Source: Created by the author

Public policies, for their part, are defined by their objectives and the instruments used. We choose below two types of classical instruments, parking policies, financing and PT fare policies to analyse their consequences in the perspective of an intermodal policy oriented by sustainable development.

5.3.3. Analysis of two intermodal policies for sustainable development

5.3.3.1. Parking policies

Parking a vehicle means appropriating for a limited time the layout of a space (on-street parking) or using a private space of one's own or made available by a third party (public park, employer, large business, etc.). In the case of on-street parking, the public authorities have direct legitimacy to intervene through rules and tariffs, since it is their own domain. The example of Yokohama show that an hourly rate for parking in public spaces can be significantly higher than the price of a bus ticket, and that pricing rules can strongly influence the choice between using PV and two-wheelers. In the case of other forms of parking, public authorities have an indirect legitimacy, since the use of individual means of travel is linked to the greater or lesser ease with which vehicles can be stored at their destination. This legitimacy is all the stronger the higher the density of the territory, since it is then that the cost of space consumption is the highest38 and conflicts over the use of public space are at their highest level. The example of Yokohama show parking policies that are at least as active as in Ile-de-France, despite lower PV fleets, with parking costs that weigh not only on the balance between PV and public transport use, but also in decisions to equip individual means of transport between car, bicycle and motorized two-wheelers.

Several cost frames of reference can be adopted to help reflection

The first is that of space consumption, which aims to charge for use according to the value of the "m²-hour consumed". This reasoning makes most sense for residential priority parking, to which must be added the control costs, which are a priori moderate for this type of parking.

The second is the rates charged in the neighbourhood by other forms of parking service provision: garage rentals, public parks, employee parking costs for employers and customer parking costs for supermarkets, etc. The second is the rates charged in the neighbourhood by other forms of parking service provision: garage rentals, public parks, employee parking costs for employers and customer parking costs for supermarkets. Depending on the case, this reference may be used for residential parking or short-term parking. In the case of short-term parking, it would be normal for the cost of on-street parking to be higher than that of public park parking because, if the parking is well managed, the parking location is closer to the final destination.

The third is the break-even price that would result from parking management aimed at the quality of service provided. It is generally believed that optimal parking management is achieved when the "vacancy rate" (the percentage of free spaces) is in the range of 5 to 7 per cent (one free space every 15 to 20 spaces). The rate at which this is achieved varies widely, both over time and across zones. It no longer necessarily reflects the cost of space consumption, but simply the political will to provide quality service.

These standards think of parking as a closed system, to be optimized in itself. This is why the recommendations resulting from these indicators must also be modulated. For example, in the absence of tolls that reflect the external costs of traffic, it is perfectly possible to consider that, on average, the destination parking fee could include a component reflecting these costs. Conversely, it can be argued that the fare charged at a feeder park may be lower than the actual cost, if that is a condition for gaining transit passengers.

[38] We keep this term of space consumption, even if the term “rental” would seem more appropriate.

Regardless of the reference systems adopted, we will make a heavy assumption in the future, that users will comply with the rules and tariffs, which implies a very significant increase in the rate of fines in Ile-de-France and in the intensity of surveillance. We can then consider a few directions that would have major consequences for the sustainability of mobility and the city

Residential priority parking pricing

This parking gives rise to an extremely low rate today (0.5€ per day in Paris, compared to 3€ for the cost of space consumption alone for 10m² for 10 hours, and compared to 100 to 300€ per month for parking in the capital's PV parks or garages). There are fairly good reasons for applying different rules for residential parking and rotary parking: to allow long-term carefree parking, to allow families with children to occupy the old, car-free park in the capital, for example. There are, however, few good reasons to justify such a distortion between the rate charged and the benchmarks presented above. This is all the truer since the use of PV by Parisians is very specific (30% of PV with no use at all during the week compared to 9% on average in France, 13 trips per week per PV used compared to 22 in France (Massot et al., 2008)) and the range of alternative offers has been greatly enriched in recent years, in particular with Vélib' and car-sharing offers. Realistic pricing at 3 or 4€ per day would have the following advantages: it would restore a market balance between on-road and off-road offers, with a price that would only partially reflect that of space consumption. It would thus free up on-street space. It would make car-sharing more competitive with ownership for small car-poolers, thus freeing up spaces again. It would stimulate the use of alternative individual modes, such as bicycles and motorized two-wheelers, or occasionally taxis, which consume less space, and PT.

Pricing and control to ensure good quality of service for rotary on-street parking

A significant part of the driving time in dense spaces is made up of parking search time, which is integrated in our study into PV journey time. The notion of search time is difficult to objectify, but the observations of Sareco, an engineering firm specializing in parking studies, suggest search times of the order of 10 minutes in downtown areas, which is considerable. With a lost time of about 30 minutes per square per day, or 10 to 12 hours per hectare, we obtain, for the city of Paris alone, an annual lost time of about 25 million hours, or about €250m. In addition to this time lost by users in search of parking, there are additional congestion costs related to the impact of the traffic of people looking for parking on the traffic of other users (some studies suggest that 5% to 10% of traffic in the city is looking for parking), as well as the double parking of delivery drivers. Achieving a target of 5 to 7% free space in all zones may result in very high fares in some zones[39], which may suggest that motorists will lose out. At least three reasons suggest that this will not be the case. First, these exceptional fares will occur in only a few very limited areas. Second, they will elicit adjustment reactions: carryovers on bicycles, motorized two-wheelers, public transport, and taxis. The search for quality of service in rotary parking through rigorous pricing would therefore have a priori positive consequences in terms of mode choice (particularly at off-peak times, because on-street parking practices are not very work-related, which does not imply an alignment of additional public transport supply). The service to the user would be improved: elimination of 10 minutes of search time and a few minutes of walking time. In addition, traffic conditions in dense areas would be improved, leading to lower external costs (pollution and congestion) where they are greatest.

[39] In London, in the Westminster district, a policy aiming at an 85% occupancy rate leads to a rate of €6/h. In Manhattan, the rate is €10/h in some areas.

The most significant disadvantage of this orientation is the high cost of monitoring. However, once the orientation is decided, investment can be made in (initially rather expensive) automated monitoring aids. This is what San Francisco does, with sensors capable of detecting whether a space is vacant or occupied, and in the latter case whether the payment is valid. The investment is $23 million. In addition, the system makes it possible to adjust fare levels to the rate of empty seats, and to communicate this information on cell phones. Moreover, payment by cell phone can make life easier for users (some of whom do not pay because they do not have change, or the city's payment card, etc.). The people in charge of control, equipped with a communicating PDA, then only have to go to the vehicles in violation.

Private parking pricing (employers, shopping malls)

The relationship between two private actors (an employer and its employees, a business and its customers) is a priori private. Concerning the supply of parking, this presupposition is debatable, since the supply of parking is the key point that allows the use of the car, and thus the formation of negative external effects (congestion, environment, etc.) and this is the reason why public authorities can impose parking standards in new construction. The question that may arise is therefore one of pricing the public and external costs of the traffic that these parking facilities allow, rather than that of parking itself.

This question only arises if this pricing function is applied to the roadway. How could it be implemented, and with what advantages/disadvantages? A first solution would be to define an annual taxation in the place offered. It has the advantage of being simple and involving few administrative costs, since one would only seek to tax sites with a large number of places (at least 20 for example), and one would seek an acceptable solution (minimalist evaluation of the related traffic and the corresponding external costs). The disadvantage is that regulation would only be based on the number of places, which is likely to change rather slowly.

A second solution would be to require that the entrance to these parking lots be equipped with a counting device, which would serve as a basis for taxation. In this case, more rapid changes could be observed, with employers or shopping centres encouraging their employees to carpool or use two-wheelers and public transport, for example.

Employer parking lots and business-related parking lots are in different situations. For the former, we know (from the work of Donald Shoup, professor at the University of California at Los Angeles) that demand is very elastic to supply conditions. The Californian sites where a simple measure has been implemented (employees who do not ask their employer for a parking card have the equivalent of the savings made by the employer added to their pay slip) have seen the number of PV arriving at the site fall by about 15%. In Ile-de-France, the problem would no doubt be to avoid transferring congestion from the roads to PT during rush hour. Less is known about the latter, except that each seat is occupied by a greater number of successive users. It is likely, however, that even a very moderate payment would induce customers to make larger "baskets" and lower the frequency of visits, or to change at the margin of mode choice. The problems of potential contribution to congestion are much more limited in this case.

Organization of parking in interchange hubs

The primary purpose of the major interchange hubs, generally in the suburbs or far suburbs, is to extend the area of attraction of the stations, based on principles of collection / grouping / splitting that are common to all logistics organizations. Conceived in the 1970s and 1980s, they have given priority to bus/rail exchanges that do not involve permanent parking and to car/rail exchanges; as soon as the customer base is even a little large, PV parking can quickly become a problem, either of saturation (and then the lack of guaranteed spaces is also the risk of missing one's train), or of long journey times (with spaces of 2m50X4, 100m make it possible to park 25 PV in length and 40 in width). The nature of the final journey (journeys usually made alone, over distances of less than 5km) argues for the use of less cumbersome modes of transport than PV (bicycle or motorized two-wheelers). There are land-based reasons, reasons for saving transfer time (it should be remembered that the disutility of this time is commonly estimated at 3 times the disutility of time in traffic), and reasons for the reliability of the journey time to the station and the time spent searching for parking.

Let's illustrate these points with an example. One person is 4km from the station. She can get there by PV or by two wheels. By car, she knows from experience that her travel time will be 10 to 14 minutes depending on traffic conditions, so she expects 14 minutes. By two-wheeler, her time will be 10 minutes with very little variability. Arriving at the train station, it can take 1 to 3 minutes to park, the two-wheeler will only take one. If 80 people have already arrived at a parking lot with a double row of side spaces served by one lane, users must park 100m from the station (90 seconds walk) if the previous users were motorists, 33m (30 seconds walk) if the previous users were two-wheelers (assuming that one PV space can be occupied by 3 two-wheelers). The difference is one minute. The externality imposed on the user by the behaviour of those who preceded him justifies (in addition to questions of available land) a priority given by the operator to the means of transport that consume the least amount of space. Between precautionary behaviour and the need to walk more, the stakes are 7 minutes, and 7 minutes is probably worth 15 minutes from the point of view of arduousness. This is a not insignificant challenge for trips from the inner suburbs to Paris (which usually take an hour all-inclusive), in addition to the challenges for the manager, who would have less land to mobilize.

Under these conditions, one could imagine a strategy aimed at developing two-wheel/rail intermodality. It would be based on the following principles:

The road network in areas located within a radius of 3 to 4km around stations is the subject of an in-depth safety analysis of two-wheeler traffic (motorized or not) and the necessary investments and management policies are put in place to ensure this safety.

The station parking offer is developed according to clear priority principles. Bicycles are parked as close as possible to the entrance, in spaces visible to pedestrians, which ensures passive safety. They are followed by spaces for motorized two-wheelers. Then follow spaces reserved for "priority" cars. Priorities can be assigned either to people with reduced mobility or to users who request them (e.g. annual season ticket holders), possibly in return for an additional fee. Finally, the rest of the spaces are available for motorists with no particular characteristics.

5.3.3.2. Financing and pricing of public transport

Strengths and weaknesses of pricing in the Ile-de-France public transportation system

A comparison between Ile-de-France, Yokohama and Kanagawa reveals the very specific character of Ile-de-France in several respects.

The first specificity is a priori positive. Employers play a role in financing public transport, and this role is justified by the fact that they are indirect beneficiaries of the transport system: by facilitating mass travel, which is still concentrated over time, public transport enables employers to benefit from large recruitment areas, which would be very difficult with individual means of travel alone. On the other hand, one may question the principle of the levy implemented. The tax base is the wage bill; the rate depends on the department in which the company is located. It is highest in Paris and the Hauts-de-Seine, at an average level in the other two departments in the inner suburbs, and at a lower level in the outer suburbs. These rates imperfectly reflect the interest that companies derive from the PT system. In particular, those far from the heavy network do not derive the same benefits as others. Nor do these rates necessarily reflect the costs they generate, because firms may have local recruitment policies or very diverse recruitment areas.

The other points of comparison are less in favour of Ile-de-France. In Ile-de-France, users pay only a small part of the accounting cost of their trip. Improving the quality of the system depends less on his or her own expectations or behaviour than on the public authorities' ability to provide the main funding, whether from general local finances or from transport payments. In Yokohama, the public authorities finance most of the heavy investment, but user revenues cover most of the operating expenses. The situation of under-pricing in Ile-de-France is all the more pronounced the longer the distance travelled. STIF considers that the fare for a 2-zone pass covers around 50% of costs, compared with only 20% for a 6-zone pass. This under-pricing is further accentuated, for the active population, by the reimbursement of half the cost of the NAVIGO pass. The public will is to encourage transfers from PV to public transport. The reality of user behaviour is rather that of a trade-off between housing quality and transport costs. The lower the latter are, the more housing can be chosen over a large area, and the more likely it is that trips, particularly to work, will be long-distance.

The third difference is that the fare level is the same in Ile-de-France for a trip by bus and subway, even though subway users, because of its higher speed, travel greater distances than bus users. In comparison, bus fares are usually lower in Yokohama than those of the subway. In Ile-de-France, therefore, it is the mode that a priori offers the lowest quality of service that costs the user the most per km travelled. This difference is particularly pronounced for marginal users, who use booklet tickets (Agenais, 2007). They then pay €0,34/km on buses, compared with €0,19 and €0,14/km on subway and RER systems. Moreover, the ticketing structure is not very diverse: tickets (single or booklet tickets for occasional users), territorially based passes, opening access to all modes of transport in the same area for regular users. This structure is a product of history. Among the major network industries, urban transport pricing principles are now an exception: electricity, TGV and air transport rates vary according to the time of consumption. Cell phone operators offer a multitude of packages, and continuity solutions in the event of overruns. In Yokohama, the electronic card allows sophisticated tariff differentiation.

Our own work, like that of A. Agenais, suggests that differences in quality of service (in travel time) between public transport and PV now largely outweigh differences in monetary cost in the formation of modal choice. On the other hand, if we assume that the parking policies mentioned above are, at least in part, implemented tomorrow, the cost of PV in dense areas will be significantly increased, and the pricing issue may play a significant role again. In addition, financial constraints will place an increasing burden on transit authorities, and user fares will have to be increased. There is no reason for such increases to be uniform across modes, territories, time periods, and types of user. This issue could be addressed through a technological innovation, with a smart card of the type used in mobile telephony, which would not only allow very detailed pricing for each trip, but also for mobility pricing over a given period (a fare that decreases with use, for example, as in Yokohama). We will not do so here, not for lack of interest, but to present the reasoning behind an intermodal and sustainable development-oriented approach to the pricing issue, in a context of structural increases in the costs of providing the service[40].

The main problems of the PT system

The following list gives our vision of the problems of PT in Ile-de-France:
- Saturation at peak times on heavy networks, particularly for travel to Paris.
- Quantitative and qualitative inadequacy of internal services in the inner suburbs, while the road network is becoming saturated.
- Insufficient frequency in off-peak hours to attract motorists outside Paris
- Significant funding difficulties in maintaining operations, even more so in developing the system.
- Tariffs that take away the responsibility of the actors (employers, users) in their location decisions, with one consequence: the inconsistency between the pricing policy of the
- PT (favourable to urban extension) and the SDRIF, which advocates the “compact city”.

5.3.3.3. Desirable changes in tariffs and financing principles

The Ile-de-France transportation system will need more money in the future, or its operation will deteriorate. How to ensure that the necessary fare increases (for employers and users alike) do not result in the underutilization of the system where it performs well for users and the community, and a shift to individual modes, is the central question we are trying to answer here.

A first response is to hunt for unnecessary expenses. There are undoubtedly many at the level of the operators, but that would be another thesis. Among those that depend on the organizing authority, two could be examined in depth:

Examination of very lightly loaded lines, which have the lowest revenue-to-cost ratio. This examination may lead to the line being simply abolished, or to different operating methods (different organization of frequencies, buses on demand, etc.) and to negotiations with the municipalities concerned for them to participate in financing, when they wish to maintain the line. Equity is not necessarily "the same service for all", but can also be an equitable contribution by regional players to local services.

Examination of the possibility of removing the 50% refunds on NAVIGO passes, for assets whose salaries exceed a certain amount, for example 3 minimum wage revenue. This measure would have very little impact on their mode choice decisions, which are much more regulated by performance in terms of time than cost.

[40] Costs could be better controlled by increasing competition and deregulation of the system. We consider here that this would be outside the subject of the thesis.

A second answer is the hunt for harmful expenses, inherited from history. An asset who lives close to his or her work and does not consider it useful to purchase a transit pass receives nothing from the community. His employer does, however, pay the transportation payment for him as for others. In 2003, an employee who lives within a reasonable distance (his migration takes place in two zones) paid 25.2€ for his monthly transit pass (after reimbursement by his employer) and the service he used cost 92.6€. The community therefore paid 67.4€ per month for him. An employee living far from work (8 zones in 2003) paid 68.5€, the service he used cost 570€ per month, so the community paid 501.5€ for him, i.e. more than the equivalent of a minimum revenue. This structure can be explained by historical considerations (the period of new cities, that of the virtues of extensive urbanization). It can also be explained today by the presence of more modest categories in the peripheries. While it is difficult to reconsider this situation for those who are already settled, who can invoke "acquired rights" and who can be easily identified, it is not unimaginable to separate their case, which can be settled by specific reimbursements, possibly degressive over time, from that of "new candidates". The gradual increase in fares on long routes, in order to equalize subsidy rates, and the limitation of employer-paid obligations to the three-zone fare, for example, would be a step in this direction. It would also be possible to devote, on an experimental basis, a modest part of the Transport Grant to residential mobility aids to help stable workers get closer to their jobs. As for employers (who have address files of their employees), they could be subject to transport payment rates modulated by the average distance of their employees from the place of employment.

A third response would aim to make life easier for occasional users, particularly those living in the inner suburbs in areas without subway service (50% of the area in the inner suburbs is considered unserved). It would consist of offering NAVIGO bus passes only, at an attractive price compared to the current NAVIGO pass.

A fourth response would be based on time regulation. We could offer "off-peak hours only" passes in the various areas of Ile-de-France, hoping to improve the rate of use at constant cost in the least busy periods and, above all, attract new customers to public transport. As for employers, one could imagine that they would claim reductions in the Versement transport when a significant proportion of jobs are taken outside peak hours.

A fifth response could be based on modal regulation. A few areas (central-western Paris and the western part of the inner suburbs, from La Défense to Rueil) benefit from the exceptional RER A service. Employers in these areas could be subject to a transportation surcharge to reflect their contribution to network saturation problems and to discourage new applicants from moving to these areas. On the user side, and particularly for users in Paris and the inner suburbs, bus-only, bus and subway-only passes could be offered at attractive fares compared with the current 2-zone pass NAVIGO to relieve congestion (a few percent at peak times changes the situation) on the RER in the central part of the network, especially since many lines provide parallel service.

Greater accountability of users and indirect beneficiaries is essential for a more financially sustainable evolution of the public transport system. This is an indispensable condition for maintaining its role in the environmentally sustainable development of mobility in Ile-de-France. If all or some of the proposed parking measures are implemented, the proposed fare changes for public transport (a general upward trend in fares, with specific downward trends in fares) will not encourage transfers to the car, and will allow a moderation in the evolution of public transport costs and a better coverage of these costs by users.

Conclusion

Although the urban form, urban transport structure, and economic level are very different in Europe and Japan, they still face the same important and unavoidable transport challenge of creating more sustainable mobility in terms of reducing dependence on motorized vehicles in central areas, increasing the attractiveness of public transport, and at the same time developing alternatives to motorized vehicles. Faced with this challenge in the city, there are several possible strategies, of which the concept of intermodality seems to be one of the useful strategies to satisfy sustainable development in the best economic and social conditions, and the recognition of the link between transport needs and urban planning.

Reminder of research objectives

Throughout this thesis work, we wanted to respond to the issue of urban transportation and the possible role of intermodality around the core of sustainable development in the current context in order to propose possible avenues of development within the framework of sustainable development. Individual motorized vehicles is globally increasing. If this trend of modal shift continues, the objective of sustainable development of urban transport will not be achieved.

In this case, we aim to look for the compatibility of transportation measures and the possibility of intermodality in order to build a more sustainable urban mobility. Thus, our work first sought to understand the general characteristics of urban mobility and the evolution of mobility in order to indicate the dependence of the use of the *passenger car, because the* spreading movements of populations and activities, as well as the evolution of living standards and rhythms, have led to a preponderant use of PV, especially for the motorized vehicle. After analysing urban mobility, we must then seek to understand the relative competition of modes and at the same time propose a possible development path for intermodality in the city at the end of the first part.

To quantify these qualitative analyses on urban mobility, the second part evaluates all the respective travel costs by activity, territory and mode linked to two evaluation approaches. Indeed, the adapted methodology is based on an accounting and economic analysis of travel for the various transport actors (users, public authorities and society). The aim is to identify the sustainable development of urban transport with regard to the triple objective of accessibility, productivity and sustainability and to evaluate, with the help of a transport diagnosis model, the various effects of specific policy scenarios. The discussion then focused on the comparison of transport modes using the results of the evaluation of travel costs in order to clarify the relationship between urban mobility and travel costs and to shed light on urban transport measures.

In addition, in the third part, we first proposed the prospects for sustainable development in Ile-de-France and Yokohama. Finally, the lessons of this work for an intermodal policy and more sustainable mobility in those two areas based on the results of travel cost assessment is our last work to explain how we can apply the cost diagnosis model to the review of transportation policies. Indeed, it is necessary to question certain habits of thought that have become obsolete and to support diversified partnerships, renew practices, share thoughts and exchange experiences beyond the boundaries of the urban area.

Across the three main parts of our research, linking qualitative and quantitative analysis around sustainable urban mobility issues, we were able to highlight key factors, enabling us to understand the brakes and levers of sustainable urban transportation development. Based on the main ideas of each of the axes, we will now attempt to outline the challenges of intermodality in the urban area and within the framework of sustainable development. In short, this final chapter consists mainly of three components: a reminder of the research objectives, the main results, and the contributions and avenues for further research to be developed.

Key findings

The aim here is to briefly review the five strong points of our research through the questions addressed on urban transportation based on the evaluation of travel costs in the context of sustainable development at different economic scales:
- the evolution of urban motorization and the competitiveness of modes;
- the complementarity of transport modes;
- the possibility of implementing intermodality;
- diagnostic elements based on the evaluation of travel costs;
- the transport measures proposed for intermodality and sustainable mobility.

Each of these points has yielded interesting results on the use of the travel cost lever.

The evolution of urban motorization

First of all, it is necessary to learn about the historical evolution of urban motorization linked to economic and demographic growth in the urban area. Indeed, most of the urban transport policies present are still aimed at seeking possible solutions to reduce the level of motorization or to alleviate the environmental impact caused by motorized vehicles in the urban area from the perspective of sustainable development. The objective of this point is twofold: the observation of the development trajectory of urban transport and the competitiveness of the modes of transport.

According to the general descriptions of motorization with regard to temporal evolution, urban form and socio-economic level, we have specified that the evolution of motorization has a similar trajectory (towards a significant use of motorized vehicles, PV and motorcycles). Moreover, this trajectory of urban motorization may accompany different urban modal forms. For this purpose, motorization studies and the trend of modal shift in the megacity can provide an initial view before transport policies are implemented.

Following the observation of urban transportation, the automobile is increasingly used in Ile-de-France compared to other modes in the city, thanks to their accessibility and affordability. In fact, the competitiveness of modes linked to geographical condition can directly reflect the order of modal choice of individuals, this observation can also be proved by the travel cost model.

Following the description of competitiveness for the use of PV, this means that PT is not attractive enough in a broad sense, especially in the suburbs. Indeed, the PT network in Ile-de-France and Yokohama are relatively developed compared to other cities in the world. For this reason, the challenges encountered in Ile-de-France and Yokohama can serve as an example for each other to consider further improvements after development of the main part of the PT network.

In addition, depending on the result of the evaluation of travel costs, the use of PT and the use of the motor vehicle have their respective advantages. For example, motorized vehicle use is normally more attractive than public transport use in terms of the cost of time and the government's summation. Conversely, public transport is more competitive than motor vehicle uses when the private cost of ownership and use and the external cost are taken into account. Following the evaluation of travel costs by territory, the competitiveness between public transport and motorized vehicles is always different according to the links in the urban area. For example, in Ile-de-France, PT is relatively more competitive than PV for trips within the Paris area, and between the Paris-PC, Paris-GC and PC-GC areas. On the other hand, for ring road trips in the suburbs, the use of motorized vehicles is probably more feasible. The competitiveness of modes is rather explained by the preferred behaviour of individuals for modal choice, the burden of public funding for the government and the level of environmental impact for society. This is why the objective of the transport carrot and stick measures is always to change the situation of modal competitiveness.

Complementarity of transportation modes

After describing the development trajectory of urban transport and economic and demographic change, the structure of urban mobility becomes increasingly stable when the economy is developed and population density is saturated. This phenomenon is well represented in the three areas studied: Ile-de-France, Yokohama and Kanagawa. For example, on the urban transport development trajectory, the structure of mobility in Ile-de-France and Yokohama remains relatively stable compared to that in some parts of Kanagawa prefecture.

Faced with a stable mobility structure in Ile-de-France and strong growth in motorization in Kanagawa prefecture, the complementarity between modes is a fundamental notion for reasonably reducing motorization dependency and at the same time satisfying the travel demands of residents. Moreover, while the need to organize the complementarity of means of transport has been repeatedly pointed out, there has been an intensification of thinking and proposals in this area in recent years, particularly for more developed cities. According to the qualitative description of the respective characteristics of the modes, the complementarity of modes theoretically has certain advantages in order to enhance the accessibility of public transport and to alleviate the environmental impact caused by the motorized vehicle in the urban area.

Moreover, we can also explain this phenomenon of the complementarity of modes by evaluating travel costs. According to the results of the evaluation of costs by activity, by mode and by territory, we can see that there are different characteristics of travel by car, motorcycle and *public transport*. In other words, the effective organization of the complementarity of transport modes can lead us to a more sustainable mobility in the urban area.

Moreover, the complementary nature of the modes can not only give passengers additional food for thought when making their modal choice, but also give them a vision of urban development linked to limited urban space and the price of land to the public authorities. To achieve this, this direction of development is twofold: one aims to free up the urban space taken up by the motorized vehicle and the other aims to reduce public spending linked to the high price of land. On the other hand, reasonable development of the road system in the suburbs can not only strengthen the weak public transport network and human activities, but also relatively reduce public expenditure on public transport infrastructure.

The possibility of implementing intermodality

The implementation of intermodality in the urban transport system is, in the broadest sense, an extension of complementing modes. Indeed, with the exception of PV, public transport only satisfies the demands of some passengers for door-to-door travel services, especially for trips in the centre. In other words, by taking advantage of the respective characteristics of the modes, intermodality can strengthen the function of public transport to provide door-to-door service to passengers, although the rate of intermodality use is still marginal.

According to the basic definition of intermodality, intermodality appears to have the potential to provide an efficient transport chain compared with some trips by passenger PV (especially for centre-suburban links) and to reduce the negative environmental impact of motor vehicle use. To do this, we proposed a possible path for the development of intermodality in the urban area: interzone trips between the centre and the suburbs linked to the use of the passenger PV (bicycle, motorcycle, PV and bus) from the origin to the train station in the suburbs and to the use of public transport (subway and train) from the station to the centre.

In addition, we have also developed strong and weak points for the use of intermodality based on the cost evaluation results. Firstly, there are two weak points for intermodality: one is the cost of travel time for users, due to the fact that travel time for intermodality is relatively higher (the increase in time outside the vehicle, such as waiting, transfer and parking time) and the other is the cost to the government, due to the need to improve the situation for connections (such as interchange hubs, park-and-ride facilities and transfer conditions in the station, etc.). As for the strengths, there are also two: one is the reduction of the environmental impact caused by the motor vehicle (pollution, noise, accidents and congestion), particularly in the central area; the other is the extension of the station's attraction area.

Although the intermodal mode has a relative attractiveness for some trips in the megacity as a result of the qualitative description and quantitative analysis, this mode occupies only a small part of the urban transport market because of the weak points in the urban transport chain. On the whole, the intermodal mode should be encouraged and made attractive in relation to the use of PV in accordance with sustainable development, since the significant extension of the PT network must depend on the capacity of the public budget. Therefore, this mode can be a complementary mode to strengthen the capacity of the PT network.

In addition, successful intermodality must be based not only on a strong and attractive PT network, but also on the efficient development of interchange hubs and park-and-ride facilities. Interchanges and park-and-ride facilities are thus a potential tool to support the operation of concentrated urban cores. On a city scale, they will also make it possible to increase and selectively manage parking capacity: long-term parking, preferably on the outskirts, theoretically freeing up central road space and parking space to be reallocated. Moreover, on this scale, a new type of analysis, based on the comparison of travel costs achieved with the different modes of transport in the different areas of the city, has enabled us to demonstrate that there are indeed geographical areas of maximum socio-economic efficiency differentiated for each of them and that a methodology for the optimal location of PV/PT interchange locations from the community's point of view can be sketched out.

Diagnostic elements based on cost evaluation

After evaluating travel costs by mode, activity and territory, we proposed diagnostic elements based on international comparison, on the global study of the different types of costs and on the spatial differentiation of costs. These diagnostic elements can give us numerical references before the implementation of transport measures for public authorities.

First of all, international comparison can explain the levels of use of individual motorized vehicles according to stages of economic development, urban development trajectories and flow control policies. Second, general diagnostic elements based on the overall study of different types of costs can respectively reflect the cost to users (private cost), to the government (government summation) and to society (external costs). These costs related to the three activities can be linked to the three perspectives on sustainable development. Indeed, the level of development of modes is always different depending on these diagnostic elements. For example, the use of PT is more economical than the use of PV for society, and the use of PT is on the contrary less attractive than the use of PV for public finances. As for users, the situation is very different depending on the type of link.

Finally, general diagnostic elements based on the spatial differentiation of costs can trace the respective competitiveness between PV, motorcycles and light rail according to the different links in the urban area. As we see that the public transport network is always concentrated in the central area, this is the reason why the total cost of PT travel in Paris, for example, is probably cheaper than PV and motorcycle. On the other hand, the PT network is weaker for ring road services in the suburbs, so the total cost of travelling by PT on the ring road in the suburbs is more expensive than by PV and motorcycle.

According to these different diagnostic elements, we can well indicate the advantages and disadvantages for the use of PV and PT by territory under the different aspects, users, public authorities and society. These results can guide transport measures within the framework of sustainable development.

Proposed transportation measures for intermodality and sustainable mobility

At the beginning of the third part of our research, we presented the perspectives proposed in Ile-de-France and Yokohama with both the numerical objectives for medium and long-term development according to the official published reports. After having noted the proposed perspectives and the quantified objectives in these two areas, the reduction of PV use in dense areas, the increase in the use of PT and non-motorized modes and the creation of alternative modes to motorized vehicles are the main axes of development in the city. In principle, these proposed measures can frame the four perspectives on the environment, on the public authorities' summation, on the efficiency of mobility and on urbanity.

To this end, we have already gridded the relationship between the development of modes and the advantages/disadvantages of modes in a modal shift perspective according to the results of evaluating the travel costs related to the various aspects (such as the monetary and temporal cost to the user, the cost to public finances and the social costs) in Ile-de-France and Yokohama. These results can guide us in a direction of mode development related to the types of links in the urban areas.

With the exception of the mode development analysis based on the evaluation of travel costs, we then made a proposal concerning the two intermodal policies for sustainable development: parking policies, financing and pricing of public transport in Ile-de-France and Yokohama. In this proposal, we also launched some possible avenues for the development of urban transport in the context of sustainable development in the urban area, such as the system of parking fees in the city, the organization of interchange hubs, the means of *public* financing of public *transport and* the modification of the public transport fare system.

Within the framework of the sustainable development of urban transportation, there are also various measures relating to urban transportation with regard to the environmental, economic and social aspects. On the whole, the coherence of urban transport measures aims not only to build a more pleasant environment for all inhabitants, but also to avoid significant waste of social resources. For this reason, reasonable short-term solutions must be sought to solve the current urban transport problem and to chart a medium- to long-term path for the future vision of urban transport development. Overall, our diagnostic model based on the assessment of travel costs seems to be suitable for examining the direction of development of measures and the coherence between measures.

Path for further research

Our research has highlighted the economic aspects raised by the issues surrounding intermodality and urban mobility based on passenger behaviour, the restriction of public funding and the impact of the external environment. At the same time, we have also established an economic analysis model that includes the multitude of relative factors across these three aspects (mobility efficiency related to the user aspect, the public authority summation related to public funding and the environment related to externalities).

Basic research approaches

To go further in the analysis, further investigations would now be necessary from a socio-economic and policy perspective. In the first register, it would be a matter of better understanding the individual practices concerned according to this type of offer (subway, bus, BRT, etc.); in the second, it would be interesting to follow the experiments carried out for the development of integrated pricing systems and possibly also the sectoral impacts that these intermodal linkages could have. Therefore, the further research path to be developed, which extends the previous work, can mainly focus on 6 tracks:

The first area in which our work has made us feel the need to deepen our knowledge is therefore that of the potential for modal transfer. We have highlighted the modal shift trajectory over the last years, and at the same time the measures related to modal shift in the context of sustainable development. Indeed, these qualitative descriptions based on local surveys and published research go in the broadest sense through elements of understanding of the state of urban mobility. It would therefore be interesting, for example, to trace the future trajectory of modal split in the urban area according to different thresholds linked to economic, environmental and social factors in the framework of sustainable development. In fact, there is still little research on urban mobility forecasting that combines the overall aspects of sustainable development with the scientific quantitative approach.

After analysing the competitiveness of modes, we can confirm that the result of travel cost evaluation related to individual choice and collective optimum can explain the structure of urban mobility, the urban transport issues encountered and the coherence of transport measures. The objective of this development path is twofold: one is to look for appropriate levers related to a different socio-economic condition to change the negative trajectory present in the framework of sustainable development, and the other is to examine the compatibility of travel cost evaluation approaches with other international studies.

A third and subsequent line of research concerns the link between environmental awareness and mobility practices. This link is not the subject of much work and would deserve to be further substantiated in future research, particularly to evaluate external factors in monetary terms. Recent research on transportation foresight indicates that most research is still dependent on environmental parameters. Moreover, we have observed that these environmental factors are the crucial points for a successful shift from motor vehicle use to PT, non-motorized mode, or intermodal mode use. In order to extend this line of research, further study is needed on the relationship between measures related to environmental impact, the internalization of external factors and the efficiency of mobility for individuals.

A fourth area for further research would be the various transport levers related to urban land use and urban transport planning to maximize social benefit. Indeed, we have already shown some measures based on travel costs to transfer motor vehicle use to PT use. According to figure II-5, we can design the transport measures related to the external impact, the quality of service of PT and public financing (such as measures related to the leverage of parking, taxes, tolls, etc.).

A fifth subsequent research track, more focused on motorized vehicles, would address the competition between conventional motorized vehicles and alternative vehicles (such as electric bicycles, electric motorcycles, electric cars, etc.). This question seems interesting to us to explore and compare complementarity, durability or practicability, by focusing on attachment to the object, an attachment that partly hinders the reduction of motorized vehicles. In this sense, it would be interesting to extend the development of alternative vehicles by analogy with PT. Another avenue for reflection would concern the relationship between intermodality and quality of life. One hypothesis would be that individuals with exclusive use of a mode would get tired of it and experience it more quickly than those who adopt intermodal practices. Greater flexibility in modal choice would lead to a better quality of life, and each mode would then be better supported over the long term. In addition, we need to continue to analyse other policies for intermodality and more sustainable mobility, with the exception of motor vehicle parking and public finance/pricing policies for public transport presented in our work.

Urban mobility is a very broad theme that invites reflection on a great deal of future research. In short, although the means of transport that this thesis has sought to approach the issues and methods of articulation and coherence focus on public transport and PV or light modes, there can be no question for us of minimizing the importance of the other modes. A desire to organize complementarity, choosing this approach, seems to us however to be a way of improving the overall functioning of the urban environment, because it brings to the forefront the need for a system analysis. Complementarity is, in particular, an attempt to rationalise the operation of each component of the transport system, which makes it possible to seek collective socio-economic optimisation while respecting a concern for social and territorial equity.

Bibliography

Articles

40 ans d'aménagement aux abords des nouvelles gares, quelles leçons pour demain. (2018). Société du Grand Paris.

Abe, S., Nakagawa, D., Matsunaka, R., & Oba, T. (2014). Study on the factors to transform underused land focusing on the influence of railway stations in central areas of Japanese Local cities. Land Use Policy, 41, 344–356.

Abours, S., Midenet, S., & Soulas, C. (2015). Rapport final du projet VERT. Le vélo évalué en rabattement dans les territoires. Volume 2. 90.

About, N. (1997). Le transport ferroviaire au Japon : quels enseignements pour l'Europe. Délégation du Sénat pour l'Union Européenne. https://www.senat.fr/rap/r97-170/r97-170_mono.html

Abraham, C. (2011). L'ouverture à la concurrence du transport ferroviaire de voyageurs (p. 154). Cabinet du Premier Ministre de la République Française.

Acharya, S. R., & Morichi, S. (2007). Managing motorization and timing of mass rapid transit in east asain megacities.

Advani, M. (2006). Bicycle – As a feeder mode for bus service. 9.

Agervig, C. T., & Ebert, A.-K. (2012). Chapter 2 Cycling Cultures in Northern Europe: From 'Golden Age' to 'Renaissance'. In J. Parkin (Ed.), Cycling and Sustainability (Vol. 1, pp. 23–58). Emerald Group Publishing Limited.

Aguilera, A., Madre, J.-L., & Mignot, D. (2004). Métropolisation, formes urbaines et mobilité. Présentation du dossier. Les Cahiers scientifiques du transport, 45, 5. https://halshs.archives-ouvertes.fr/halshs-00068411

Akar, G., Fischer, N., & Namgung, M. (2013). Bicycling Choice and Gender Case Study: The Ohio State University. International Journal of Sustainable Transportation, 7(5), 347–365.

Akimura, S. (2015). Transportation statistics that can contribute to policies and social infrastructure development aimed at ensuring the healthy growth of cities and providing support for smooth economic activity. IATSS Research, 39(1), 9–18.

Akyelken, N., Banister, D., & Givoni, M. (2018). The sustainability of shared mobility in London: The dilemma for governance. Sustainability, 10(2), 420.

Albert de la Bruhèze, Adri A., Veraart, F.C.A., & Technology, Innovation & Society. (1999). Fietsverkeer in praktijk en beleid in de twintigste eeuw. In Rijkswaterstaat-serie (Vol. 63). Ministerie van Verkeer en Waterstaat. https://research.tue.nl/nl/publications/fietsverkeer-in-praktijk-en-beleid-in-de-twintigste-eeuw(d4e24b80-32ae-4ffd-91f5-22c9b58551c7).html

Aldred, R. (2013). Who are Londoners on Bikes and what do they want? Negotiating identity and issue definition in a 'pop-up' cycle campaign. Journal of Transport Geography, 30, 194–201.

Aldred, R., & Jungnickel, K. (2013). Matter in or out of place? Bicycle parking strategies and their effects on people, practices and places. Social & Cultural Geography, 14(6), 604–624.

Aldred, R., & Jungnickel, K. (2014). Why culture matters for transport policy: The case of cycling in the UK. Journal of Transport Geography, 34, 78–87.

Aldred, R., Woodcock, J., & Goodman, A. (2016). Does More Cycling Mean More Diversity in Cycling? Transport Reviews, 36(1), 28–44.

Alexander, M., & Hamilton, K. (2015). A 'placeful' station? The community role in place making and improving hedonic value at local railway stations. Transportation Research Part A: Policy and Practice, 82, 65–77.

Alexandersson, G., & Rigas, K. (2013). Rail liberalisation in Sweden. Policy development in a European context. Research in Transportation Business & Management, 6, 88–98.

Allen, P., Rouphail, N., & Hummer, J. (1998). Operational analysis of uninterrupted bicycle facilities. https://journals.sagepub.com/doi/abs/10.3141/1636-05

Amagasa, S., Fukushima, N., Kikuchi, H., Ohya, Y., Odagiri, Y., Takamiya, T., Oka, K., Kitabatake, Y., & Inoue, S. (2017). Sociodemographic, biological, psychological, and behavioural correlates of cycling in community-dwelling Japanese older adults: A cross-sectional study. 8.

Amar, G. (2010). Homo mobilis: Le nouvel âge de la mobilité : éloge de la reliance. FYP editions.

Amoros, E., Chiron, M., Martin, J.-L., Thélot, B., & Laumon, B. (2012). Bicycle helmet wearing and the risk of head, face, and neck injury: A French case–control study based on a road trauma registry. Injury Prevention, 18(1), 27–32.

Andersen, L. B., Schnohr, P., Schroll, M., & Hein, H. O. (2000). All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work. Archives of Internal Medicine, 160(11), 1621–1628.

Andersson, E. V., Peterson, A., & Törnquist Krasemann, J. (2013). Quantifying railway timetable robustness in critical points. Journal of Rail Transport Planning & Management, 3(3), 95–110.

Ando, R., Yamazaki, M., Haraand, M., & Izuhara, K. (2012). An Analysis on Feasibility of Park & Cycle Ride System in a Japanese Local City. Procedia - Social and Behavioural Sciences, 54, 37–46.

Andrade, K., & Kagaya, S. (2011). Cycling in Japan and Great Britain: A Preliminary Discussion. 12.

Appleyard, D., Gerson, M. S., & Lintell, M. (1976). Liveable urban streets: Managing auto traffic in neighborhoods. Department of Transportation, Federal HIghway Administration.

Arbis, D., Rashidi, T. H., Dixit, V. V., & Vandebona, U. (2016). Analysis and planning of bicycle parking for public transport stations. International Journal of Sustainable Transportation, 10(6), 495–504.

Aron, M., Boillot, F., & Lebacque, J. P. (2004). Modelisation du trafic. Actes du groupe de travail 2002. Actes INRETS, N97. https://trid.trb.org/view/945574

Aronson, S. H. (1951). The sociology of the bicycle. Social Forces, 30, 305.

Ascher, F. (2007). Multimobility, multispeed cities: A challenge for architects, town planners, and politicians. 6.

Atmani, D. (2015a). Affectation dynamique dans les systèmes de transport multimodaux. Université Paris Est.

Atmani, D. (2015b). Towards the introduction of an autonomous transportation line in a multimodal transportion system. 9.

Auzanneau, M. (2016). Or noir: La grande histoire du pétrole. La Découverte.

Auzannet, P., & Maubois, R. (1988). Un compte transport de voyageurs pour la région d'Ile-de-France. Un Compte Transport de Voyageurs Pour La Région d'Ile-de-France, 2, 41–53.

Aveline, N. (1997). Tokyo et ses projets urbains / Tokyo and her urban projects. Revue de géographie de Lyon, 72(2), 117–121.

Aveline, N. (2000). Yûichirô Itô. Informations sur la régénération de Tokyo. Ebisu - Études Japonaises, 24(1), 147–150.

Aveline, N. (2002). L'expérience particulière du Japon en matière de renouvellement urbain. 8.

Aveline, N. (2005). Diversification extra-ferroviaire et mise en valeur du patrimoine foncier du groupe JR East à Tokyo, vers le modèle de la 'compagnie ferroviaire généraliste'? 12.

Aveline-Dubach, N. (2015). Vieillissement et déprise urbaine au Japon. In Post-Print (halshs-01242578; Post-Print). HAL. https://ideas.repec.org/p/hal/journl/halshs-01242578.html

Averous, B., Coulon, A., & Durand, J. (1977a). Recherche sur une nouvelle pratique du deux roues dans différents groupes socio-culturels. Beterem.

Averous, B., Coulon, A., & Durand, J. (1977b). Recherche sur une nouvelle pratique du deux roues dans différents groupes socio-culturels. Beterem.

Axhausen, K. W., & Bhat, C. (2005). Travel behaviour research and connection choice. Transportation Research Part A: Policy and Practice, 39(4), 277–278.

Bachand-Marleau, J., Larsen, J., & El-Geneidy, A. M. (2011). Much-Anticipated Marriage of Cycling and Transit: How Will It Work? Transportation Research Record: Journal of the Transportation Research Board, 2247(1), 109–117.

Bambrick, Y. (2015). The urban cycling survival guide, need-to-know skills and strategies for biking in the city. ECW Press.

Banister, C., Turner, J., Richardson, T., & Rees Jeffreys Road Fund. (2000). Unravelling the transport web: Delivering the new transport realism in a complex policy environment : a report on the wider policy conflicts that exist in the transport 'web'. Landor.

Banister, D. (Ed.). (1995). Transport and urban development. E & FN Spon.

Banister, D. (Ed.). (2000). European transport policy and sustainable mobility. Spon Press.

Banister, D. (2005). Unsustainable Transport (0 ed.). Routledge.

Banister, D. (2008). The sustainable mobility paradigm. Transport Policy, 15(2), 73–80.

Banister, D. (2009). Sustainable Transport and Public Policy. Trasnport Engeneering and Planning, 2, 192–214.

Banister, D., & Banister, D. (2002). Transport planning. Spon. http://site.ebrary.com/id/10099292

Banister, D., & Berechman, J. (2000). Transport Investment and Economic Development.

Banister, D., & Button, K. (Eds.). (1991). Transport in a Free Market Economy. Palgrave Macmillan UK.

Barles, S. (2017). Écologie territoriale et métabolisme urbain: Quelques enjeux de la transition socioécologique. Revue d'Économie Régionale & Urbaine, Décmbr(5), 819–836.

Barles, S., & Guillerme, A. (1998). La congestion urbaine en France (1800-1970). https://halshs.archives-ouvertes.fr/halshs-00280970

Barrington, A., & Howe, J. D. G. F. (1977). Valuing Time Savings in Developing Countries (Comment and Rejoinder). Journal of Transport Economics and Policy, 11(2), 195–201.

Batabyal, A. A., & Nijkamp, P. (2013). Ought a green citizen to bicycle or take public transport to work? Ecological Economics, 86, 93–96.

Bates, J., Polak, J., Jones, P., & Cook, A. (2001). The valuation of reliability for personal travel. Transportation Research Part E: Logistics and Transportation Review, 37(2), 191–229.

Batten, D. F., Fischer, M. M., Hewings, G. J. D., Nijkamp, P., & Snickars, F. (1995). Advances in Spatial Science. 233.

Becker, G. S. (1965). A Theory of the Allocation of Time. The Economic Journal, 75(299), 493–517.

Beitel, D., Stipancic, J., Manaugh, K., & Miranda-Moreno, L. (2018). Assessing safety of shared space using cyclist-pedestrian interactions and automated video conflict analysis. Transportation Research Part D: Transport and Environment, 65, 710–724.

Bejarano, M., Ceballos, L. M., & Maya, J. (2017). A user-centred assessment of a new bicycle sharing system in Medellin. Transportation Research Part F: Traffic Psychology and Behaviour, 44, 145–158.

Berger, M., & Dörrzapf, L. (2018). Sensing comfort in bicycling in addition to travel data. Transportation Research Procedia, 32, 524–534.

Beria, P., Quinet, E., de Rus, G., & Schulz, C. (2012). A comparison of rail liberalisation levels across four European countries. Research in Transportation Economics, 36(1), 110–120.

Berloco, N., & Colonna, P. (2012). Testing and Improving Urban Bicycle Performance. Procedia - Social and Behavioural Sciences, 53, 72–83.

Bernal, L. M. M. D. (2016). Basic Parameters for the Design of Intermodal Public Transport Infrastructures. Transportation Research Procedia, 14, 499–508.

Bhouri, N., & Scemama, G. (2003). Intermodality in urbain management systems: State of the art. 6.

Bieber, A., Massot, M.-, & Orfeuil, J.-. (1993). Questions vives pour une prospective de la mobilite quotidienne. Synthese INRETS, 19. https://trid.trb.org/view/1005999

Bigo, A. (2019). Comment décarboner les transports en France d'ici 2050, présentation des résultats intermédiaires de thèse.

Bihouix, P., & Guillebon, B. de. (2010). Quel futur pour les métaux? Raréfaction des métaux: un nouveau défi pour la société. EDP sciences.

Black, J. A., & Rimmer, P. J. (1982). Japanese highway planning: A western interpretation. Transportation, 11(1), 29–49.

Black, W. R. (1996). Sustainable transportation: A US perspective. Journal of Transport Geography, 4(3), 151–159.

Blainey, S. P., & Preston, J. M. (2013). A GIS-based appraisal framework for new local railway stations and services. Transport Policy, 25, 41–51.

Bonanomi, L., & Bonanomi-Schaffner, L. (1990). Le temps des rues: Vers un nouvel aménagement de l'espace rue. IREC.

Bondada, M. V. A. (2000). Urban Public Transportation Systems: Implementing Efficient Urban Transit Systems and Enhancing Transit Usage. https://cedb.asce.org/CEDBsearch/record.jsp?dockey=0123272

Bonin, H. (2016). France-Japon, regards croisés. Mélanges en l'honneur de Terushi Hara [Review of France-Japon, regards croisés. Mélanges en l'honneur de Terushi Hara, by D. Barjot & P. Fridenson]. Revue Historique, 679, 720–722.

Bonnafous, A. (1996). Le système des transports urbains. Economie et Statistique / Economics and Statistics, 294–295, 99–108.

Bonnin, P., Masatsugu, N., & Shigemi, I. (2014). Vocabulaire de la spatialité japonaise. In Http://journals.openedition.org/lectures (CNRS). CNRS. http://journals.openedition.org/lectures/13938

Bopp, M., Sims, D., & Piatkowski, D. (2018). Bicycling for transportation: An evidence-base for communities.

Boquet, Y. (2010). Changing mobilities in Asian cities. 21.

Boquet, Y. (2012). Can Western mobility solutions apply to East Asia's cities? 22.

Boske, L. B. (1998). Multimodal/Intermodal Transportation in the United States, Western Europe, and Latin America: Governmental Policies, Plans, and Programs, PRP 130 [Technical Report]. LBJ School of Public Affairs. https://repositories.lib.utexas.edu/handle/2152/20825

Bouf, D., & Hensher, D. A. (2007). The dark side of making transit irresistible: The example of France. Transport Policy, 14(6), 523–532.

Bouleau, M., & Coureau, J. (2013). Peak-car: La baisse de la mobilité automobile est-elle durable ? https://www.institutparisregion.fr/nos-travaux/publications/peak-car-la-baisse-de-la-mobilite-automobile-est-elle-durable.html

Bouteiller, C. (2015). Différenciation tarifaire dans les réseaux de transports urbains et interurbains de voyageurs: Quels apports pour les services publics de transport et l'aménagement ? [Theses, université Lyon 2]. https://hal.archives-ouvertes.fr/tel-01144063

Bouzaïene-Ayari, B., Gendreau, M., & Nguyen, S. (2001). Modeling Bus Stops in Transit Networks: A Survey and New Formulations. Transportation Science, 35(3), 304–321.

Bracher, T., Krafft-Neuhäuser, H., & Preußer, H.-P. (1988). Radverkehrspolitik und Radverkehrsanlagen in Europa. Policy and provision for cyclists in Europe. XVIII, 130 S., Anl. https://repository.difu.de/jspui/handle/difu/130911

Brand, J., Hoogendoorn, S., van Oort, N., & Schalkwijk, B. (2017). Modelling multimodal transit networks integration of bus networks with walking and cycling. 2017 5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS), 750–755.

Brands, T., de Romph, E., Veitch, T., & Cook, J. (2014). Modelling Public Transport Route Choice, with Multiple Access and Egress Modes. Transportation Research Procedia, 1(1), 12–23.

Bras, H. L. (2019). La voiture, les " gilets jaunes " et le Rassemblement national. 15.

Brès, A., & Desjardins, X. (2014). Quelles alternatives à l'automobile dans les espaces d'" entre-villes " ? Une comparaison franco-allemande. Annales de géographie, 698(4), 1039.

Brons, M., Givoni, M., & Rietveld, P. (2009). Access to railway stations and its potential in increasing rail use. Transportation Research Part A: Policy and Practice, 43(2), 136–149.

Bruntlett, M., & Bruntlett, C. (2018). Building the Cycling City: The Dutch Blueprint for Urban Vitality. Island Press.

Buehler, R. (2012). Determinants of bicycle commuting in the Washington, DC region: The role of bicycle parking, cyclist showers, and free car parking at work. Transportation Research Part D: Transport and Environment, 17(7), 525–531.

Buehler, R., & Pucher, J. (2012). Walking and Cycling in Western Europe and the United States. 9.

Buehler, R., Pucher, J., & Altshuler, A. (2017). Vienna's path to sustainable transport. International Journal of Sustainable Transportation, 11(4), 257–271.

Buehler, R., Pucher, J., & Dümmler, O. (2019). Verkehrsverbund: The evolution and spread of fully integrated regional public transport in Germany, Austria, and Switzerland. International Journal of Sustainable Transportation, 13(1), 36–50.

Buehler, R., Pucher, J., Gerike, R., & Götschi, T. (2017). Reducing car dependence in the heart of Europe: Lessons from Germany, Austria, and Switzerland. Transport Reviews, 37(1), 4–28.

Buekers, J., Dons, E., Elen, B., & Int Panis, L. (2015). Health impact model for modal shift from car use to cycling or walking in Flanders: Application to two bicycle highways. Journal of Transport & Health, 2(4), 549–562.

Buhler, T. (2012). Eléments pour la prise en compte de l'habitude dans les pratiques de déplacements urbains. Le cas des résistances aux injonctions au changement de mode de déplacement sur l'agglomération lyonnaise.

Buhnik, S. (2010). From Shrinking Cities to Toshi no Shukushō: Identifying Patterns of Urban Shrinkage in the Osaka Metropolitan Area. Berkeley Planning Journal, 23(1).

Buiter, H., Staal, P.E., & Algemene Wetenschappen. (2003). Traffic lights as signs of the regulated street. The introduction and the diffusion of traffic lights in Dutch cities between 1880 and 1940. TM2 Conference Eindhoven, November 6-9, 2003.

https://research.tue.nl/nl/publications/traffic-lights-as-signs-of-the-regulated-street-the-introduction-and-the-diffusion-of-traffic-lights-in-dutch-cities-between-1880-and-1940(d9998d9e-ec6b-4738-9263-2678670bd28f).html

Bullock, C., Brereton, F., & Bailey, S. (2017). The economic contribution of public bike-share to the sustainability and efficient functioning of cities. Sustainable Cities and Society, 28, 76–87.

Burgess, J. (2008). A Comparative Analysis of the Park-and-Ride/ Transit-Oriented Development Tradeoff. 75.

Burton, E., Jenks, M., & Williams, K. (2003). The Compact City: A Sustainable Urban Form?. http://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=181079

Bussiere, Y., & Madre, J.-. (2002). Demographie et transport: Villes du nord et villes du sud. https://trid.trb.org/view/957145

BUSSIERE, Y., MADRE, J.-L., ARMOOGUM, J., & BERNARD, A. (1997). Motorisation et intermodalité: Une comparaison Montréal - Paris. Motorisation et Intermodalité : Une Comparaison Montréal - Paris, 381, 4, 30-40 [12 p.].

Caggiani, L., Camporeale, R., Ottomanelli, M., & Szeto, W. Y. (2018). A modeling framework for the dynamic management of free-floating bike-sharing systems. Transportation Research Part C: Emerging Technologies, 87, 159–182.

Calafiore, G. C., Portigliotti, F., & Rizzo, A. (2017). A Network Model for an Urban Bike Sharing System * *This work is partially supported by Compagnia di San Paolo, Italy. The kind cooperation of Bicincittà – ToBike in providing us with logged service data is gratefully acknowledged. IFAC-PapersOnLine, 50(1), 15633–15638.

Calimente, J. (2012). Rail integrated communities in Tokyo. Journal of Transport and Land Use, 5(1), 19–32.

Callens, S. (1996). Erreurs fatales. Alliage, 28, 80–84.

Calthorpe, P. (2011). Urbanism in the age of climate change. Island Press.

Calthorpe, P., & Fulton, W. B. (2001). The Regional City: Planning for the end of sprawl. Island Press.

Cantos, P., Manuel Pastor, J., & Serrano, L. (2012). Evaluating European railway deregulation using different approaches. Transport Policy, 24, 67–72.

Capo, C. (2013). Proximité et commerce en gare, la consommation en gare au Japon.pdf. 1–3.

Carel, L. (2019). Analyse de données volumineuses dans le domaine du transport. École Nationale de la Statistique et de l'Administration Économique.

Carlo, P. (2016). Étude thématique sur la gestion des gares ferroviaires de voyageurs en France. ARAFER.

Carr, J., & Dionisio, M. R. (2017). Flexible spaces as a "third way" forward for planning urban shared spaces. Cities, 70, 73–82.

CARRE, J.-R. (1992). Les obstacles à l'usage du vélo, aspects sociologiques. Le Vélo, Un Enjeu Pour La Ville, 8–12.

Carré, J.-R. (1998). Le vélo dans la ville: Un révélateur social. Les cahiers de mediologie, N° 5(1), 151–164.

Carse, K. (1994). Bicycling for ladies. Cycle History: Proceedings of the 4th International Cycle History Conference, 107–112.

Cartenì, A. (2014). The catchment area of high architectural railway stations: An application of the Graham scan algorithm (G. Galante & I. Henke, Eds.; pp. 463–474).

Cartenì, Armando, Pariota, L., & Henke, I. (2017). Hedonic value of high-speed rail services: Quantitative analysis of the students' domestic tourist attractiveness of the main Italian cities. Transportation Research Part A: Policy and Practice, 100, 348–365.

Cascetta, E., & Cartenì, A. (2014). The hedonic value of railways terminals. A quantitative analysis of the impact of stations quality on travellers behaviour. Transportation Research Part A: Policy and Practice, 61, 41–52.

Castán Broto, V., & Baker, L. (2018). Spatial adventures in energy studies: An introduction to the special issue. Energy Research & Social Science, 36, 1–10.

Castillo-Manzano, J. I., Castro-Nuño, M., & López-Valpuesta, L. (2015). Analyzing the transition from a public bicycle system to bicycle ownership: A complex relationship. Transportation Research Part D: Transport and Environment, 38, 15–26.

Castillo-Manzano, J. I., López-Valpuesta, L., & Sánchez-Braza, A. (2016). Going a long way? On your bike! Comparing the distances for which public bicycle sharing system and private bicycles are used. Applied Geography, 71, 95–105.

Castro, A., Kahlmeier, S., & Gotschi, T. (2018). Exposure-Adjusted Road Fatality Rates for Cycling and Walking in European Countries (International Transport Forum Discussion Papers No. 2018/05; International Transport Forum Discussion Papers, Vol. 2018/05).

Caulfield, B. (2014). Re-cycling a city – Examining the growth of cycling in Dublin. Transportation Research Part A: Policy and Practice, 61, 216–226.

Çelebi, D., Yörüsün, A., & Işık, H. (2018). Bicycle sharing system design with capacity allocations. Transportation Research Part B: Methodological, 114, 86–98.

Centre d'études sur les réseaux, l'urbanisme et les constructions publiques (France). (2012). La mobilité urbaine en France: Enseignements des années 2000-2010.

Cervero, R., Caldwell, B., & Cuellar, J. (2013). Bike-and-Ride: Build It and They Will Come. Journal of Public Transportation, 16(4), 83–105.

Cervero, R., & Golub, A. (2007). Informal transport: A global perspective. Transport Policy, 14(6), 445–457.

Chakhtoura, C., & Pojani, D. (2016). Indicator-based evaluation of sustainable transport plans: A framework for Paris and other large cities. Transport Policy, 50, 15–28.

Chassignet, M. (2016). Etude d'évaluation sur les services vélos, enquête sur le stationnement sécurisé intermodal (p. 46).

Chen, C., Xia, J. (Cecilia), Smith, B., Olaru, D., Taplin, J., & Han, R. (2015). Influence of Parking on Train Station Choice under Uncertainty for park-and-ride Users. Procedia Manufacturing, 3, 5126–5133.

Chen, P., Liu, Q., & Sun, F. (2018). Bicycle parking security and built environments. Transportation Research Part D: Transport and Environment, 62, 169–178.

Chen, X., Liu, Z., Hua, D., & Kim, I. (2017). A New Model for Rail-Based Park-And-Ride with Feeder Bus Services. Transportation Research Procedia, 21, 79–86.

Cheng, Y.-H., & Liu, K.-C. (2012). Evaluating bicycle-transit users' perceptions of intermodal inconvenience. Transportation Research Part A: Policy and Practice, 46(10), 1690–1706.

Cherki, E., & Mehl, D. (1979). Les Nouveaux Embarras de Paris: De la révolte des usagers des transports aux mouvements de défense. FeniXX.

Chevroulet, T., Fournier, P., Mounier, Y., Berthelot, O., Zhang, C., Monsigny, M., Wilken, D., Stader, A., & Ortmann, C. (1999). Potentials of new technologies in transport scenarios: Alternative technologies- intermodality- telematics & information technologies, scenarios project, 4th framework programme, strategic research. Infoscience, Article REP_WORK. http://infoscience.epfl.ch/record/27905

Chriqui, C., & Robillard, P. (1975). Common Bus Lines. Transportation Science.

Christiansen, L. B., Cerin, E., Badland, H., Kerr, J., Davey, R., Troelsen, J., van Dyck, D., Mitáš, J., Schofield, G., Sugiyama, T., Salvo, D., Sarmiento, O. L., Reis, R., Adams, M., Frank, L., & Sallis, J. F. (2016). International comparisons of the associations between objective measures of the built environment and transport-related walking and cycling: IPEN adult study. Journal of Transport & Health, 3(4), 467–478.

Clais, A.-M. (1998). Portrait de femmes en cyclistes ou l'invention du féminin pluriel. Les cahiers de mediologie, N° 5(1), 69–79.

Clayton, W., & Musselwhite, C. (2013). Exploring changes to cycle infrastructure to improve the experience of cycling for families. Journal of Transport Geography, 33, 54–61.

Cole-Hunter, T., Donaire-Gonzalez, D., Curto, A., Ambros, A., Valentin, A., Garcia-Aymerich, J., Martínez, D., Braun, L. M., Mendez, M., Jerrett, M., Rodriguez, D., de Nazelle, A., & Nieuwenhuijsen, M. (2015). Objective correlates and determinants of bicycle commuting propensity in an urban environment. Transportation Research Part D: Transport and Environment, 40, 132–143.

Colville-Andersen, M. (2018). Copenhagenize: The Definitive Guide to Global Bicycle Urbanism. Island Press/Center for Resource Economics.

Cominetti, R., & Correa, J. (2001). Common-Lines and Passenger Assignment in Congested Transit Networks. Transportation Science, 35(3), 250–267.

Conca, K., & Dabelko, G. D. (2018). Green Planet Blues: Critical Perspectives on Global Environmental Politics. Routledge.

Coolen, T. (2017). Bicycle Parking at Train Stations. NHTV University of Applied Science.

Corcoran, J., Li, T., Rohde, D., Charles-Edwards, E., & Mateo-Babiano, D. (2014). Spatio-temporal patterns of a Public Bicycle Sharing Program: The effect of weather and calendar events. Journal of Transport Geography, 41, 292–305.

Cornejo, L., Perez, S., Cheu, R. L., & Hernandez, S. (2014). An Approach to Comprehensively Evaluate Potential Park and Ride Facilities. International Journal of Transportation Science and Technology, 3(1), 1–18.

Cornelis, E., Hubert, M., Huynen, P., Lebrun, K., Patriarche, G., Witte, A. D., Creemers, L., Declercq, K., Janssens, D., Castaigne, M., Hollaert, L., & Walle, F. (2012). La mobilité en Belgique en 2010: Résultats de l'enquête BELDAM. https://researchportal.unamur.be/en/publications/la-mobilit%C3%A9-en-belgique-en-2010-r%C3%A9sultats-de-lenqu%C3%AAte-beldam

Costa, P. B., Neto, G. C. M., & Bertolde, A. I. (2017). Urban Mobility Indexes: A Brief Review of the Literature. Transportation Research Procedia, 25, 3645–3655.

Cour des comptes. (2018). SNCF réseau, des réformes à approfondir (p. 99). Cour des comptes.

Coutard, O., Dupuy, G., & Fol, S. (2002). La pauvreté périurbaine: Dépendance locale ou dépendance automobile ? Espaces et sociétés, 108(1), 155.

Cox, P. (2019). Rethinking Bicycle Histories. Invisible Bicycle, 23–47.

Crest, T. D., & Clément, L. (1999). Les logiciels de planification des déplacements urbains: Catalogue (p. 94 pages, illustrations, tableaux, 7 références bibliographiques) [Report]. Centre d'études sur les réseaux, les transports, l'urbanisme et les constructions publiques (CERTU). https://hal-lara.archives-ouvertes.fr/hal-02162313

Crozet, Y. (2016). Vitesse et mobilité: Au-delà du désenchantement d'un "'monde fini'". Transports, 495, 10.

Crozet, Y. (2017a). Appraisal methodologies and the limits to speed gains. Transportation Research Procedia, 25, 2898–2912.

Crozet, Y. (2017b). Economie de la vitesse: Ivan Illich revisité. L Economie politique, N° 76(4), 24.

Crozet, Y., Lopez-Ruiz, H. G., Chateau, B., & Bagard, V. (2008). Comment satisfaire les objectifs internationaux de la France en termes d'émissions de gaz à effet de serre et de pollution transfrontières ? Programme de recherche consacré à la construction de scénarios de mobilité durable. Rapport final. https://halshs.archives-ouvertes.fr/halshs-00293725

Crozet, Y., Vickerman, R. W., France, & Programme de recherche et de développement technologique transports terrestres. (2016). Hyper-mobilité et politiques publiques: Changer d'époque? Economica.

Cui, Y., Mishra, S., & Welch, T. F. (2014). Land use effects on bicycle ridership: A framework for state planning agencies. Journal of Transport Geography, 41, 220–228.

Cycling in the Netherlands. (2009). Ministerie van verkeer en waterstaat.

d'Arcier, B. F. (2003). Urban Transport in France: Moving to a Sustainable Policy. Senshû Daigaku Shakai Kagaku Kenkyûjo Geppô, 481, 11. https://halshs.archives-ouvertes.fr/halshs-00069621

da Sousa, P. (Ed.). (2016). Structures and Architecture: Beyond their Limits. CRC Press.

Dacko, S. G., & Spalteholz, C. (2014). Upgrading the city: Enabling intermodal travel behaviour. Technological Forecasting and Social Change, 89, 222–235.

Damant-Sirois, G., & El-Geneidy, A. M. (2015). Who cycles more? Determining cycling frequency through a segmentation approach in Montreal, Canada. Transportation Research Part A: Policy and Practice, 77, 113–125.

Dang Vu, H., & Jeaneau, H. (2008). Concevoir un espace de transit et de consommation: La gestion de site dans les gares parisiennes. Espaces et sociétés, 135(4), 45.

Darin, M. (1988). Les grandes percées urbaines du XIXe siècle: Quatre villes de province. Annales. Histoire, Sciences Sociales, 43(2), 477–505.

Daudén, F. J. L., Carpio-Pinedo, J., & García-Pastor, A. (2014). Transport Interchange and Local Urban Environment Integration. Procedia - Social and Behavioural Sciences, 160, 215–223.

D'Autume, A. (2001). Évaluation des coûts unitaires des déplacements routiers à partir du compte satellite des transports. Évaluation Des Coûts Unitaires Des Déplacements Routiers à Partir Du Compte Satellite Des Transports, 133, 13–18.

Dávalos, D., Maldonado, D., & Polit, D. J. (2016). The Hidden Potential behind the City Planned for Cars. Procedia Engineering, 145, 924–931.

De Angelis, M., Stuiver, A., Fraboni, F., Prati, G., Puchades, V. M., Fassina, F., de Waard, D., & Pietrantoni, L. (2019). Green wave for cyclists: Users' perception and preferences. Applied Ergonomics, 76, 113–121.

de Cea, J., & Fernández, E. (1993). Transit Assignment for Congested Public Transport Systems: An Equilibrium Model. Transportation Science, 27(2), 133–147.

de Jong, G., Kroes, E., Plasmeijer, R., & Sanders, P. (2004). The value of reliability. 18.

de Palma, A., & Fontan, C. (2001). Choix modal et valeurs du temps en Île-de-France. Recherche - Transports - Sécurité, 71, 24–46.

de Souza, A. A., Sanches, S. P., & Ferreira, M. A. G. (2014). Influence of Attitudes with Respect to Cycling on the Perception of Existing Barriers for Using this Mode of Transport for Commuting. Procedia - Social and Behavioural Sciences, 162, 111–120.

De Vos, J. (2015). The influence of land use and mobility policy on travel behaviour: A comparative case study of Flanders and the Netherlands. Journal of Transport and Land Use, 8(1), 171.

De Vos, J., Van Acker, V., & Witlox, F. (2014). The influence of attitudes on Transit-Oriented Development: An explorative analysis. Transport Policy, 35, 326–329.

Debizet, G., Tabourdeau, A., Gauthier, C., & Menanteau, P. (2016). Spatial processes in urban energy transitions: Considering an assemblage of Socio-Energetic Nodes. Journal of Cleaner Production, 134, 330–341.

Debrezion, G., Pels, E., & Rietveld, P. (2009). Modelling the joint access mode and railway station choice. Transportation Research Part E: Logistics and Transportation Review, 45(1), 270–283.

DeMaio, P. (2009). Bike-sharing: History, Impacts, Models of Provision, and Future. Journal of Public Transportation, 12(4).

Demoli, Y. (2015a). Carbone et tôle froissée: L'espace social des modèles de voitures. Revue française de sociologie, 56(2), 223.

Demoli, Y. (2015b). Automobile et stratification sociale: Diffusion, caractéristiques et coûts de l'équipement automobile en France depuis les années 1980 [These de doctorat, Paris, Institut d'études politiques]. https://www.theses.fr/2015IEPP0004

Deng, L., Gao, W., Zhou, W., & Lai, T. (2013). Optimal Design of Feeder-bus Network Related to Urban Rail Line based on Transfer System. Procedia - Social and Behavioural Sciences, 96, 2383–2394.

Depigny, B., & Richer, C. (2016). La nouvelle donne des réformes territoriales sur les mobilités: Vers un tournant intermodal ? Revue Infrastructures et Mobilité, 161. https://halshs.archives-ouvertes.fr/halshs-01386602

DeSerpa, A. C. (1971). A Theory of the Economics of Time. The Economic Journal, 81(324), 828–846.

Desmaris, C. (2014). The reform of passenger rail in Switzerland: More performance without competition. Research in Transportation Economics, 48, 290–297.

Dewilde, T., Sels, P., Cattrysse, D., & Vansteenwegen, P. (2013). Robust railway station planning: An interaction between routing, timetabling and platforming. Journal of Rail Transport Planning & Management, 3(3), 68–77.

Dewilde, T., Sels, P., Cattrysse, D., & Vansteenwegen, P. (2014). Improving the robustness in railway station areas. European Journal of Operational Research, 235(1), 276–286.

Dial, R. B. (1967). Transit pathfinder algorithm. Highway Research Record, 205. https://trid.trb.org/view/134151

DiGioia, J., Watkins, K. E., Xu, Y., Rodgers, M., & Guensler, R. (2017). Safety impacts of bicycle infrastructure: A critical review. Journal of Safety Research, 61, 105–119.

Dijk, M., & Montalvo, C. (2011). Policy frames of Park-and-Ride in Europe. Journal of Transport Geography, 19(6), 1106–1119.

Dill, J. (2004). Measuring Network Connectivity for Bicycling and Walking. 20.

Dill, J., & Carr, T. (2003). Bicycle Commuting and Facilities in Major U.S. Cities. 9.

Diziain, D., Taniguchi, E., & Dablanc, L. (2014). Urban Logistics by Rail and Waterways in France and Japan. Procedia - Social and Behavioural Sciences, 125, 159–170.

Doherty, B., Paterson, M., Plows, A., & Wall, D. (2003). Explaining the fuel protests. The British Journal of Politics and International Relations, 5(1), 1–23.

Dondi, G., Simone, A., Lantieri, C., & Vignali, V. (2011). Bike Lane Design: The Context Sensitive Approach. Procedia Engineering, 21, 897–906.

Dreifuss, M. (1995). Le stationnement des véhicules automobiles dans les centres urbains: La genèse d'un service public [These de doctorat, Lyon 2]. https://www.theses.fr/1995LYO22001

Dreyfus, S. E. (1969). An Appraisal of Some Shortest-Path Algorithms. Operations Research, 17(3), 395–412.

Duchemin, E. (2004). Benoît Lambert, Cyclopolis, ville nouvelle: Contribution à l'histoire de l'écologie politique. Genève, Suisse, Éditeur Goerg, Collection Stratégies énergétiques, biosphère et société, 289 p., 2004. VertigO - la revue électronique en sciences de l'environnement. http://journals.openedition.org/vertigo/4775

Duc-Nghiem, N., Hoang-Tung, N., Kojima, A., & Kubota, H. (2018). Modeling cyclists' facility choice and its application in bike lane usage forecasting. IATSS Research, 42(2), 86–95.

Ducom, E. (2007). Vieillissement et aménagement du territoire: Le laboratoire japonais. Population & Avenir, 683(3), 4.

Duncan, M. (2019). Would the replacement of park-and-ride facilities with transit-oriented development reduce vehicle kilometers traveled in an auto-oriented US region? Transport Policy, 81, 293–301.

Duncan, M., & Christensen, R. K. (2013). An analysis of park-and-ride provision at light rail stations across the US. Transport Policy, 25, 148–157.

Duncan, M., & Cook, D. (2014). Is the provision of park-and-ride facilities at light rail stations an effective approach to reducing vehicle kilometers traveled in a US context? Transportation Research Part A: Policy and Practice, 66, 65–74.

Dupuy, G. (1999). La dépendance automobile: Symptômes, analyses, diagnostic, traitements. Anthropos.

Dupuy, G. (2002). L'homme à toutes vitesses. De la lenteur homogène à la rapidité différenciée. Annales de géographie, 111(623), 101–101.

Dupuy, G., & Gallez, C. (2018). La dépendance automobile. Retour sur la genèse du concept et ses enjeux politiques. Flux, 111–112(1), 104.

Durand, J.-P. (2018). Christophe Midler, Bernard Jullien et Yannick Lung, Innover à l'envers. Repenser la stratégie et la conception dans un monde frugal, Préface de Carlos Ghosn, Paris, Dunod, 216 p. La nouvelle revue du travail, 12, Article 12. http://journals.openedition.org/nrt/3639

Duranton, S., Audier, A., & Hazan, J. (2012). The 2012 European Railway Performance Index: Understanding What Drives High Performance. 12.

Duthilleul, J.-M. (2012). Circuler. Quand nos mouvements façonnent la ville. https://www.decitre.fr/livres/circuler-9782862277271.html

Ebert, A. (2004). Cycling towards the nation:the use of the bicycle in Germany and the Netherlands, 1880–1940. European Review of History: Revue Européenne d'histoire, 11(3), 347–364.

Ebert, A.-K. (2004). Cycling towards the nation:the use of the bicycle in Germany and the Netherlands, 1880–1940. European Review of History: Revue Européenne d'histoire, 11(3), 347–364.

Ebert, A.-K. (2012). When cycling gets political: Building cycling paths in Germany and the Netherlands, 1910–40. The Journal of Transport History, 33(1), 115–137.

Egami, S., Kawamura, T., & Ohsuga, A. (2016). Building Urban LOD for Solving Illegally Parked Bicycles in Tokyo. In P. Groth, E. Simperl, A. Gray, M. Sabou, M. Krötzsch, F. Lecue, F. Flöck, & Y. Gil (Eds.), The Semantic Web – ISWC 2016 (Vol. 9982, pp. 291–307). Springer International Publishing.

Elefteriadou, L. (Ageliki). (2016). The Highway Capacity Manual 6th Edition: A Guide for Multimodal Mobility Analysis (Vol. 86). https://trid.trb.org/view/1403977

Eliasson, J. (2004). Car drivers' valuations of travel time variability, unexpected delays and queue driving. Proceeding of European Transport Conference, 2004. http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-77221

Elshater, A. M., & Ibraheem, F. (2014). From Typology Concept to Smart Transportation Hub. Procedia - Social and Behavioural Sciences, 153, 531–541.

Émangard, P.-H. (2012). Les streetcars en Europe: Une vision diachronique. Transports urbains, N° 120(1), 3–8.

Emanuel, M. (2010). Understanding conditions for bicycle traffic through historical inquiry: The case of stockholm. 16.

Emberger, G., Pfaffenbichler, P., Jaensirisak, S., & Timms, P. (2008). "Ideal" decision-making processes for transport planning: A comparison between Europe and South East Asia. Transport Policy, 15(6), 341–349.

Emond, C. R., Tang, W., & Handy, S. L. (2009). Explaining Gender Difference in Bicycling Behaviour. Transportation Research Record: Journal of the Transportation Research Board, 2125(1), 16–25.

Enoch, M., & Nakamura, H. (2008). Transport policy and organization in Japan. Transport Reviews, 28(2), 159–180.

Eom, S., & Suzuki, T. (2019). Spatial distribution of pedestrian space in central Tokyo: Regarding building, public transportation and urban renewal projects. International Review for Spatial Planning and Sustainable Development, 7(2), 108–124.

Estival, J.-P. (2012). L'ultralibéralisme de la Commission européenne confronté au réalisme économique: Le cas de l'industrie ferroviaire européenne. Vie & sciences de l'entreprise, 190(1), 122.

Estival, L., & Musy, M. (2017). Vivons la ville autrement: Des villes durables où il fait bon vivre au quotidien. Editions Quae.

Faghih-Imani, A., & Eluru, N. (2015). Analysing bicycle-sharing system user destination choice preferences: Chicago's Divvy system. Journal of Transport Geography, 44, 53–64.

Faghih-Imani, A., & Eluru, N. (2016). Determining the role of bicycle sharing system infrastructure installation decision on usage: Case study of montreal BIXI system. Transportation Research Part A: Policy and Practice, 94, 685–698.

Faghih-Imani, A., Eluru, N., El-Geneidy, A. M., Rabbat, M., & Haq, U. (2014). How land-use and urban form impact bicycle flows: Evidence from the bicycle-sharing system (BIXI) in Montreal. Journal of Transport Geography, 41, 306–314.

Faugier, E. (2017). The Necessity of Slowing Time: Speed as a Bridge between Transport History and Mobility History. Mobility in History, 8(1).

Fehr, E. (2002). Altruistic punishment in humans. 415, 4.

Fels, M. F. (1975). Comparative energy costs of urban transportation systems. Transportation Research, 9(5), 297–308.

Feng, Y., Affonso, R. C., & Zolghadri, M. (2017). Analysis of bike sharing system by clustering: The Vélib' case. IFAC-PapersOnLine, 50(1), 12422–12427.

Fernández-Heredia, Á., Monzón, A., & Jara-Díaz, S. (2014). Understanding cyclists' perceptions, keys for a successful bicycle promotion. Transportation Research Part A: Policy and Practice, 63, 1–11.

Feuardant, P., & Codina, S. (2017). La recherche sur la ville durable au Japon (p. 24). Ambassade de France au Japon.

Feuillet, T., Salze, P., Charreire, H., Menai, M., Enaux, C., Perchoux, C., Hess, F., Kesse-Guyot, E., Hercberg, S., Simon, C., Weber, C., & Oppert, J.-M. (2016). Built environment in local relation with walking: Why here and not there? Journal of Transport & Health, 3(4), 500–512.

Flonneau, M. (2003). L'action du district de la région parisienne et les " Dix Glorieuses de l'urbanisme automobile ", 1963-1973. Vingtieme Siecle. Revue d'histoire, no 79(3), 93–104.

Flonneau, M. (2012). Victoire modale, victoire morale ? Le système automobile dans le jeu des transports publics parisiens au début du XXe siècle. Histoire urbaine, n° 33(1), 107–117.

François, B. (2011). Shinjuku NO. ENSAPB.

FRENAY, P. (2001). P R versus urbanisation autour des noeuds de transports publics. P R versus Urbanisation Autour Des Noeuds de Transports Publics, 166, 20–29.

Freudendal-Pedersen, M. (2015). Whose Commons are Mobilities Spaces? – The Case of Copenhagen's Cyclists. 24.

Frick, R. (2003). Effizienz von öffentlichen Investitionen in den Langsamverkehr, für das Bundesamt für Straßen (ASTRA). Bern, Schweiz.

Fridell, E., Haeger-Eugensson, M., Moldanova, J., Forsberg, B., & Sjöberg, K. (2014). A modelling study of the impact on air quality and health due to the emissions from E85 and petrol fuelled cars in Sweden. Atmospheric Environment, 82, 1–8.

Frijhoff, W., Schuyt, K., & Spies, M. (2004). Dutch Culture in a European Perspective: 1950, prosperity and welfare. Uitgeverij Van Gorcum.

Fröidh, O. (2003). Introduction of regional high speed trains: A study of the effects of the Svealand line on the travel market, travel behaviour and accessibility. http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-3507

Fruin, J. J. (1971). Pedestrian planning and design (206 pp). Article 206 pp. https://trid.trb.org/view/114653

Fujii, S. (2005). Reducing Inappropriate Bicycle Parking Through Persuasive Communication. Journal of Applied Social Psychology, 35(6), 1171–1196.

Fujii, S., & Taniguchi, A. (2005). Reducing family car-use by providing travel advice or requesting behavioural plans: An experimental analysis of travel feedback programs. Transportation Research Part D: Transport and Environment, 10(5), 385–393.

Fujii, S., & Taniguchi, A. (2006). Determinants of the effectiveness of travel feedback programs—A review of communicative mobility management measures for changing travel behaviour in Japan. Transport Policy, 13(5), 339–348.

Fukuda, D., & Morichi, S. (2007). Incorporating aggregate behaviour in an individual's discrete choice: An application to analyzing illegal bicycle parking behaviour. Transportation Research Part A: Policy and Practice, 41(4), 313–325.

Furness, Z. M. (2010). One less car: Bicycling and the politics of automobility. Temple University Press.

Furth, P. G., Mekuria, M. C., & Nixon, H. (2016). Network Connectivity for Low-Stress Bicycling. Transportation Research Record: Journal of the Transportation Research Board, 2587(1), 41–49.

Füssl, E., & Haupt, J. (2017). Understanding cyclist identity and related interaction strategies. A novel approach to traffic research. Transportation Research Part F: Traffic Psychology and Behaviour, 46, 329–341.

Gaboriau, P. (1991). Les trois âges du vélo en France. Vingtième Siècle. Revue d'histoire, 29(1), 17–34.

Gaget, A. (2016). Le péage urbain de Stockholm: Aujourd'hui accepté par la population malgré une implantation mouvementée?

Gallez, C., Kaufmann, V., Maksim, H., Thébert, M., & Guerrinha, C. (2013). Coordonner transport et urbanisme. Visions et pratiques locales en Suisse et en France. Revue d'Économie Régionale & Urbaine, avril(2), 317.

García-Palomares, J. C., Gutiérrez, J., & Latorre, M. (2012). Optimizing the location of stations in bike-sharing programs: A GIS approach. Applied Geography, 35(1–2), 235–246.

Gardon, S. (2009). Gouverner la circulation urbaine: Des villes françaises face à l'automobile (années 1910-années 1960) [PhD Thesis].

Gatersleben, B., & Appleton, K. M. (2007). Contemplating cycling to work: Attitudes and perceptions in different stages of change. Transportation Research Part A: Policy and Practice, 41(4), 302–312.

Gebhardt, L., Krajzewicz, D., Oostendorp, R., Goletz, M., Greger, K., Klötzke, M., Wagner, P., & Heinrichs, D. (2016). Intermodal Urban Mobility: Users, Uses, and Use Cases. Transportation Research Procedia, 14, 1183–1192.

Gehl, J. (2010). Cities for people. Island Press.

Gérard, W. (1991). Les deux-roues légers: Sécurité et aménagements. Sécurité Des Routes et Des Rues.

Gerardin, M. (2013). Indemnité kilométrique vélo, Les enjeux, les impacts. http://www.villes-cyclables.org/modules/kameleon/upload/ciduv_2013nov_rapport_indemintes_kilometriques.pdf

Gerondeau, C. (1979). La mort inutile. FeniXX.

Geurs, K., Robusté, F., La Paix, L., Rangel, T., & Pritchard, J. (2018). Smart cities and value of time: An International Symposium. Ciencia, Ingenierías y Aplicaciones, 1(1), 71–78.

Geurs, K. T., La Paix, L., & Van Weperen, S. (2016). A multi-modal network approach to model public transport accessibility impacts of bicycle-train integration policies. European Transport Research Review, 8(4), 25.

Ghosh, G. (2015). Light rail transit in Mysore: Complimenting land use and transport. In C. A. Brebbia (Ed.), WIT Transactions on The Built Environment (1st ed., Vol. 1, pp. 949–959). WIT Press.

Giffard, P. (1891). La reine Bicyclette: Histoire du vélocipéde; depuis les temps les plus reculés jusqu'a nos jours. Firmin-Didot.

Giffard, P., Robida, A., & Robida, A. (1899). La fin du cheval. A. Colin.

Gifford, C. D. S. (1992). Frances E. Willard, How I Learned to Ride the Bicycle: Reflections of an Influential 19th Century Woman. Methodist History, 30(2), 117–119.

Gilbert, R., & Perl, A. (2007). Transport revolutions: Moving people and freight without oil. Earthscan.

Givoni, M., & Rietveld, P. (2007). The access journey to the railway station and its role in passengers' satisfaction with rail travel. Transport Policy, 14(5), 357–365.

Givoni, M., & Rietveld, P. (2014). Do cities deserve more railway stations? The choice of a departure railway station in a multiple-station region. Journal of Transport Geography, 36, 89–97.

Gleyze, J.-F. (2003). La desserte de Paris par le réseau de métro et de RER.

Godard, F. (2001). La ville en mouvement (p. 128). Gallimard. https://halshs.archives-ouvertes.fr/halshs-00438996

Goetzke, F., & Rave, T. (2011). Bicycle Use in Germany: Explaining Differences between Municipalities with Social Network Effects. Urban Studies, 48(2), 427–437.

Golbuff, L., & Aldred, R. (2011). Cycling policy in the UK: A historical and thematic overview. University of East London Sustainable Mobilities Research Group. http://rachelaldred.org/wp-content/uploads/2012/10/cycling-review1.pdf

Gonzalo-Orden, H., Linares, A., Velasco, L., Díez, J. M., & Rojo, M. (2014). Bikeways and Cycling Urban Mobility. Procedia - Social and Behavioural Sciences, 160, 567–576.

Goodman, A., & Cheshire, J. (2014). Inequalities in the London bicycle sharing system revisited: Impacts of extending the scheme to poorer areas but then doubling prices. Journal of Transport Geography, 41, 272–279.

Goodwin, P. B. (1976). Human Effort and the Value of Travel Time. Journal of Transport Economics and Policy, 10(1), 3–15.

Gössling, S. (2013). Urban transport transitions: Copenhagen, City of Cyclists. Journal of Transport Geography, 33, 196–206.

Gössling, S., & Choi, A. S. (2015). Transport transitions in Copenhagen: Comparing the cost of cars and bicycles. Ecological Economics, 113, 106–113.

Gotschi, T. (2011). Costs and Benefits of Bicycling Investments in Portland, Oregon. Journal of Physical Activity and Health, 8(s1), 49–58.

Granier, B. (2017). Circulations transnationales et transformations de l'action publique: La mobilisation des sciences comportementales dans la politique énergétique japonaise (2010-2016). Université Lyon 2.

Grundy, C., Steinbach, R., Edwards, P., Wilkinson, P., & Green, J. (2008). Mph zones and road safety in London: A report to the London Road Safety Unit. LSHTM, London.

Guidez, J.-M. (2007). Les chiffres de… 2007: Le tournant du vélo ? Transports urbains, N° 111(2), 14–15.

Guidez, J.-M., Hubert, M., & Mermoud, F. (2003). Le vélo dans les villes francaises. 4 S. https://repository.difu.de/jspui/handle/difu/130929

Guihéry, L. (2014). Competition in regional passenger rail transport in Germany (Leipzig) and lessons to be drawn for France. Research in Transportation Economics, 48, 298–304.

Guihéry, L. (2004). Le réseau ferroviaire: Du monopole naturel à la régionalisation. Région et Développement, 18, 171. https://halshs.archives-ouvertes.fr/halshs-00076617

Guillerme, A. (1992). Éléments d'histoire de la congestion des voiries. Actes Du Séminaire Villes et Transports, Paris.

Guillerme, A., & Barles, S. (1998). Histoire, statut et administration de la voirie urbaine. Guide Pratique de La Voirie Urbaine.

Guit, A. (1993). Facilities for bicycle parking. C.R.O.W. Record 9. Cycling in the City, Pedalling in the Polder. Recent Developments in Policy and Research for Bicycle Facilities in the Netherlands. https://trid.trb.org/view/385488

Gunn, H. (2001). Spatial and temporal transferability of relationships between travel demand, trip cost and travel time. Transportation Research Part E: Logistics and Transportation Review, 37(2), 163–189.

Hagai, M. (2007). Reconstitution de l'autonomie de la ville et démocratie participative. 22.

Haine, C. (2011). The urban biking handbook. Quarry Books.

Haladin, S., & Antic, M. (2003). The importance of social sciences in the education of civil engineers. 4.

Hammond, V., & Musselwhite, C. (2013). The Attitudes, Perceptions and Concerns of Pedestrians and Vulnerable Road Users to Shared Space: A Case Study from the UK. Journal of Urban Design, 18(1), 78–97.

Hamre, A., & Buehler, R. (2014). Commuter Mode Choice and Free Car Parking, Public Transportation Benefits, Showers/Lockers, and Bike Parking at Work: Evidence from the Washington, DC Region. Journal of Public Transportation, 17(2), 67–91.

Handy, S., Cao, X., & Mokhtarian, P. (2005). Correlation or causality between the built environment and travel behaviour? Evidence from Northern California. Transportation Research Part D: Transport and Environment, 10(6), 427–444.

Hanley, R. E. (2004). Moving People, Goods, and Information in The 21st Century: The Cutting-Edge Infrastructures of Networked Cities. 389.

Harms, L., Bertolini, L., & te Brömmelstroet, M. (2014). Spatial and social variations in cycling patterns in a mature cycling country exploring differences and trends. Journal of Transport & Health, 1(4), 232–242.

Hassenteufel, P. (2005). De la comparaison internationale à la comparaison transnationale. Revue francaise de science politique, Vol. 55(1), 113–132.

Hatori, T., Mikiya, S., Fujii, S., & Fukuda, D. (2011). An examination on the effects of communication measures against large-scale problems of illegal bicycle parking: A case study on akabane station, east japan railway company.

Haustein, S., & Nielsen, T. A. S. (2016). European mobility cultures: A survey-based cluster analysis across 28 European countries. Journal of Transport Geography, 54, 173–180.

Hayakawa, H., Fischbeck, P. S., & Fischhoff, B. (2000). Traffic accident statistics and risk perceptions in Japan and the United States. Accident Analysis & Prevention, 32(6), 827–835.

Hayashi, Y., Nakai, N., & Numata, M. (2014). Study on the discontinuity in the bicycle network in Japan. Journal of the City Planning Institute of Japan, 49(3). https://trid.trb.org/view/1328964

Hecker, A. (2007). Urbanisme, société et mobilité durable en Allemagne. Revue Géographique de l'Est, 47(vol. 47 / 1), Article 1.

Heesch, K. C., Giles-Corti, B., & Turrell, G. (2015). Cycling for transport and recreation: Associations with the socio-economic, natural and built environment. Health & Place, 36, 152–161.

Hein, C., Diefendorf, J., & Ishida, Y. (Eds.). (2003). Rebuilding urban Japan after 1945. Palgrave Macmillan UK. https://www.palgrave.com/gp/book/9780333659625

Hein, Carola. (2006). Cities, Autonomy, and Decentralization in Japan (1st ed.). Routledge.

Heinberg, R. (2011). The End of Growth: Adapting to Our New Economic Reality. New Society Publishers.

Heinen, E. (2011). Bicycle Commuting. TU Delft, Architecture and the Built Environment.

Heinen, E., Maat, K., & Wee, B. van. (2011). The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances. Transportation Research Part D: Transport and Environment, 16(2), 102–109.

Heinen, E., van Wee, B., & Maat, K. (2010). Commuting by Bicycle: An Overview of the Literature. Transport Reviews, 30(1), 59–96.

Heins, I., & Wazlak, K. (2010). Berlin: Le succès du vélo, un défi pour les transports publics ! Berlin: Le Succès Du Vélo, Un Défi Pour Les Transports Publics !, 59(4), 44–46.

Hénaut, A. (2006). Les transports urbains en France, des solutions techniques mais une gestion politique est nécessaire (p. 40). Science & déicison.

Hensher, D. A. (2000). Measurement of valuation of travel time savings. ITS-WP-00-13. https://trid.trb.org/view/1162953

Heran, F. (1995). La ville cyclable concept, conditions et impacts. 25.

Héran, F. (2001). La réduction de la dépendance automobile—HERAN Frédéric.pdf. Cahiers Lillois d'Economie et de Sociologie, 37, 61–86.

Héran, F. (2002). Vélo et politique globale de déplacements durables (p. 114). PREDIT.

Héran, F. (2003a). Les effets pervers des parcs relais. In Post-Print (halshs-00196637; Post-Print). HAL. https://ideas.repec.org/p/hal/journl/halshs-00196637.html

Héran, F. (2003b). Les effets pervers des parcs relais. In Post-Print (halshs-00196637; Post-Print). HAL. https://ideas.repec.org/p/hal/journl/halshs-00196637.html

Héran, F. (2004a). Commerces de centre-ville et de proximité et modes non motorisés. In Post-Print (halshs-00285636; Post-Print). HAL. https://ideas.repec.org/p/hal/journl/halshs-00285636.html

Héran, F. (2004b). Commerces de centre-ville et de proximité et modes non motorisés. In Post-Print (halshs-00285636; Post-Print). HAL. https://ideas.repec.org/p/hal/journl/halshs-00285636.html

Héran, F. (2009a). À propos de la vitesse généralisée des transports. Un concept d'Ivan Illich revisité. Revue d'Économie Régionale & Urbaine, juillet(3), 449.

Héran, F. (2009b). Des distances à vol d'oiseau aux distances réelles ou de l'origine des détours. Flux, n° 76-77(2), 110–121.

Héran, F. (2011). Pour une approche systémique des nuisances liées aux transports en milieu urbain. POUR UNE APPROCHE SYSTÉMIQUE DES NUISANCES LIÉES AUX TRANSPORTS EN MILIEU URBAIN', 59, 83–112, 114–115, 117 [33 p.].

Héran, F. (2013a). À pied ou à vélo ? Ferrare ou La Rochelle ? Transports urbains, N° 122(2), 11–11.

Héran, F. (2013b). La consommation d'espace-temps des transports en milieu urbain.

Héran, F. (2014). Le retour de la bicyclette, une histoire des déplacements urbains en Europe de 1817 à 2050. La Découverte.

Héran, F. (2017). Les deux-roues motorisés en milieu urbain solution ou problème? Transports Urbains, 2, 14–19.

Héran, F. (2018). La ville morcelée. Effets de coupure en milieu urbain.

Hérault, B., Vilmart, C., & Frankreich (Eds.). (2003). Transports urbains: Quelles politiques pour demain? Documentation Française.

Hernandez, S., & Monzon, A. (2016). Key factors for defining an efficient urban transport interchange: Users' perceptions. Cities, 50, 158–167.

Hickman, R., & Banister, D. (2014). Transport, Climate Change and the City. 401.

Higgins, C. D., & Kanaroglou, P. S. (2016). A latent class method for classifying and evaluating the performance of station area transit-oriented development in the Toronto region. Journal of Transport Geography, 52, 61–72.

Hitoshi, T. (2003). Le droit de l'urbanisme au Japon. 10.

Hivert, L., Madre, J. L., Lecouvey, F., & Bourriot, F. (2006). Bilan gaz a effet de serre de l'etalement urbain. RAPPORT DE CONVENTION DAEI/SESP. https://trid.trb.org/view/940711

Holmgren, J., & Merkel, A. (2017). Much ado about nothing? – A meta-analysis of the relationship between infrastructure and economic growth. Research in Transportation Economics, 63, 13–26.

Hood, C. (2006). Shinkansen: From Bullet Train to Symbol of Modern Japan (1st ed.). Routledge.

Hook, W., & Replogle, M. (1996). Motorization and non-motorized transport in Asia. Land Use Policy, 13(1), 69–84.

Horton, D. D., Rosen, D. P., & Cox, D. P. (2012). Cycling and society. Ashgate Publishing, Ltd.

Horton, D., & Parkin, J. (2012). Conclusion: Towards a revolution in cycling. In Cycling and sustainability. Emerald Group Publishing Limited.

Hubert, M. (2008). L'Expo 58 et le " tout à l'automobile ". Quel avenir pour les grandes infrastructures routières urbaines à Bruxelles ? Brussels Studies. La revue scientifique pour les recherches sur Bruxelles / Het wetenschappelijk tijdschrift voor onderzoek over Brussel / The Journal of Research on Brussels.

Huguenin-Richard, F. (2010). La mobilité des enfants à l'épreuve de la rue: Impacts de l'aménagement de zones 30 sur leurs comportements. Enfances, Familles, Générations, 12, 66–87.

Hull, A., & O'Holleran, C. (2014a). Bicycle infrastructure: Can good design encourage cycling? Urban, Planning and Transport Research, 2(1), 369–406.

Hull, A., & O'Holleran, C. (2014b). Bicycle infrastructure: Can good design encourage cycling? Urban, Planning and Transport Research, 2(1), 369–406.

Hunt, J. D., & Abraham, J. E. (2007). Influences on bicycle use. Transportation, 34(4), 453–470.

Huré, M. (2009). La création d'un réseau de villes: Circulations, pouvoirs et territoires. Le cas du Club des Villes Cyclables (1989-2009). Métropoles, 6, Article 6.

Hyodo, T., Suzuki, N., & Takahashi, K. (2000). Modeling of Bicycle Route and Destination Choice Behaviour for Bicycle Road Network Plan. Transportation Research Record: Journal of the Transportation Research Board, 1705(1), 70–76.

Ieda, H. (Ed.). (2010). Sustainable Urban Transport in an Asian Context (Vol. 9). Springer Japan.

Ieda, H., & Kato, H. (2006). A model of bicycle-user's behaviour in access-transport to railway station.

Illich, I. (1974a). Energy and equity. Harper and Row, Publishers, Inc.,New York. https://www.osti.gov/biblio/7269671

Illich, I. (1974b). Energy and equity. https://www.osti.gov/biblio/7269671

Imashiro, M. (1997). Changes in Japan's Transport Market and JNR Privatization. 4.

Inclusive city cycling—Women, reducing the gender gap (p. 11). (2018). Sustrans.

Jabot, D. (2006). Déplacements domicile-travail: Un desserrement de l'emploi parisien vers la grande couronne. http://www.epsilon.insee.fr/jspui/bitstream/1/4519/1/alap265.pdf

Jackson, W. B., & Jucker, J. V. (1982). An Empirical Study of Travel Time Variability and Travel Choice Behaviour. Transportation Science, 16(4), 460–475.

Jancovici, J.-M. (2012). Les limites énergétiques de la croissance. Le Debat, n° 171(4), 80–95.

Janic, M. (2006). Sustainable Transport in the European Union: A Review of the Past Research and Future Ideas. Transport Reviews, 26(1), 81–104.

Jara-Díaz, S. R. (1991). Income and taste in mode choice models: Are they surrogates? Transportation Research Part B: Methodological, 25(5), 341–350.

Jayakrishnan, R., McNally, M. G., & Marar, A. G. (1995). Recursive structure for exact line probabilities and expected waiting times in multipath transit assignment. Transportation Research Record, 1493. https://trid.trb.org/view/452608

Jensen, A. (2013). Controlling mobility, performing borderwork: Cycle mobility in Copenhagen and the multiplication of boundaries. Journal of Transport Geography, 30, 220–226.

Jensen, P., Rouquier, J.-B., Ovtracht, N., & Robardet, C. (2010). Characterizing the speed and paths of shared bicycle use in Lyon. Transportation Research Part D: Transport and Environment, 15(8), 522–524.

Jiang, M., & Morikawa, T. (2004a). Theoretical analysis on the variation of value of travel time savings. Transportation Research Part A: Policy and Practice, 38(8), 551–571.

Jiang, M., & Morikawa, T. (2004b). Theoretical analysis on the variation of value of travel time savings. Transportation Research Part A: Policy and Practice, 38(8), 551–571.

Jingxu, C., Xuewu, C., Wei, W., & Baol, F. (2013). The Demand Analysis of Bike-and-ride in Rail Transit Stations based on Revealed and Stated Preference Survey. Procedia - Social and Behavioural Sciences, 96, 1260–1268.

Jones, D. (2008). Mass motorization + mass transit: An American history and policy analysis (Vol. 46). Indiana University Press. http://choicereviews.org/review/10.5860/CHOICE.46-4042

Jones, P. (2009). Link and Place: A New Approach to Street Planning and Design. 11.

Jones, Peter, Marshall, S., & Boujenko, N. (2008). Creating more people-friendly urban streets through 'link and place' street planning and design. IATSS Research, 32(1), 14–25.

Jones, W., & Brown, M. (2016). A cycling revolution. Treadlie, 19, 74.

Julien, A. (2000). Comparaison des principaux manuels européens d'aménagements cyclables: Aménagement cyclable et espace urbain (p. 122 pages, figures, tableaux, illustrations, graphiques, bibliographie pages 87 à 92) [Report]. Centre d'études sur les réseaux, les transports, l'urbanisme et les constructions publiques (CERTU). https://hal-lara.archives-ouvertes.fr/hal-02162046

Julien, A., & Carré, J.-R. (2002). Cheminements piétonniers et exposition au risque. Recherche - Transports - Sécurité, 76, 173–189.

Jurewicz, C., Sobhani, A., Woolley, J., Dutschke, J., & Corben, B. (2016). Exploration of Vehicle Impact Speed – Injury Severity Relationships for Application in Safer Road Design. Transportation Research Procedia, 14, 4247–4256.

Kager, R., Bertolini, L., & Te Brömmelstroet, M. (2016). Characterisation of and reflections on the synergy of bicycles and public transport. Transportation Research Part A: Policy and Practice, 85, 208–219.

Kager, Roland, & Harms, L. (2017). Synergies from improved cycling-transit integration towards an integrated urban mobility system (p. 36). International Transport Forum.

Kaltenbrunner, A., Meza, R., Grivolla, J., Codina, J., & Banchs, R. (2010). Urban cycles and mobility patterns: Exploring and predicting trends in a bicycle-based public transport system. Pervasive and Mobile Computing, 6(4), 455–466.

Kamiya, M. (2012). Media representations of a woman riding a bicycle: From Miura Tamaki to Hara Setsuko. 演劇研究, 36, 1–17.

Kamleh, H. (2008). La nouvelle organisation ferroviaire face au marché: Quelles leçons tirer des expériences récentes de réforme ? Revue d'économie industrielle, 124, 101–120.

Kamruzzaman, Md., Baker, D., Washington, S., & Turrell, G. (2014). Advance transit oriented development typology: Case study in Brisbane, Australia. Journal of Transport Geography, 34, 54–70.

Kanai, A. (2005). Les gares françaises et japonaises, une recherche comparative. Ecole Nationale des Ponts et Chaussées.

Karamychev, V., & van Reeven, P. (2011). Park-and-ride: Good for the city, good for the region? Regional Science and Urban Economics, 41(5), 455–464.

Karndacharuk, A., Wilson, D. J., & Dunn, R. (2014). A Review of the Evolution of Shared (Street) Space Concepts in Urban Environments. Transport Reviews, 34(2), 190–220.

Kato, H. (2014a). Policy Evaluation System for Reduction of CO2 Emissions in Transport Sector (p. 19).

Kato, H. (2014b). Urban rail development in Tokyo from 2000 to 2010. International Transport Forum.

Kato, H. (2014c). Valuation of urban rail service, experiences from Tokyo. International Transport Forum.

Kato, H. (2016). Challenges in Better Co-ordinating Tokyo's Urban Rail Services (International Transport Forum Discussion Papers) [International Transport Forum Discussion Papers].

Kato, H., Kaneko, Y., & Soyama, Y. (2014). Economic benefits of urban rail projects that improve travel-time reliability: Evidence from Tokyo, Japan. Transport Policy, 35, 202–210.

Katoshevski-Cavari, R., Bak, N., & Shiftan, Y. (2018). Would free park-and-ride with a free shuttle service attract car drivers? Case Studies on Transport Policy, 6(2), 206–213.

Kawasaki, S. (2015). The challenges of transportation/traffic statistics in Japan and directions for the future. IATSS Research, 39(1), 1–8.

Kelly, K. L. (1998). A systems approach to identifying decisive information for sustainable development. European Journal of Operational Research, 109(2), 452–464.

Kenworthy, J. R., Laube, F. B., Newman, P., Barter, P., Raad, T., Poboon, C., & Guia Jr, B. (1999). An international sourcebook of automobile dependence in cities, 1960-1990. https://trid.trb.org/view/648499

Khisty, C. J. (1993). Transportation in developing countries: Obvious problems, possible solutions. Transportation Research Record, 1396, 44–49.

Khreis, H., Warsow, K. M., Verlinghieri, E., Guzman, A., Pellecuer, L., Ferreira, A., Jones, I., Heinen, E., Rojas-Rueda, D., Mueller, N., Schepers, P., Lucas, K., & Nieuwenhuijsen, M. (2016). The health impacts of traffic-related exposures in urban areas: Understanding real effects, underlying driving forces and co-producing future directions. Journal of Transport & Health, 3(3), 249–267.

Kido, E. M. (2006). Railway Landscape Design and Relationship with Form, Function and Aesthetic. 9.

Kim, T. J. (2009). Transportation Engineering and Planning—Volume II. EOLSS Publications.

Kishii, T. (2016). Utilization of underground space in Japan. Tunnelling and Underground Space Technology, 55, 320–323.

Klinger, T., Kenworthy, J. R., & Lanzendorf, M. (2013). Dimensions of urban mobility cultures – a comparison of German cities. Journal of Transport Geography, 31, 18–29.

Koglin, T. (2015). Organisation does matter – planning for cycling in Stockholm and Copenhagen. Transport Policy, 39, 55–62.

Koglin, T., & Rye, T. (2014). The marginalisation of bicycling in Modernist urban transport planning. Journal of Transport & Health, 1(4), 214–222.

Köhler, J., Geels, F. W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M. S., … Wells, P. (2019). An agenda for sustainability transitions research: State of the art and future directions. Environmental Innovation and Societal Transitions, 31, 1–32.

Koike, H. (1991). Current Issues and Problems of Bicycle Transport in Japan. 7.

Koike, H. (2014). Mobility perspective for a local city in Japan. IATSS Research, 38(1), 32–39.

Koike, H., Morimoto, A., & Itoh, K. (2000). A study on measures to promote bicycle usage in Japan. 7.

Kondoh, S., Kurakawa, K., Kato, S., Umeda, Y., Takata, S., National Institute of Advanced Industrial Science and Technology (AIST), 1-2-1 Namiki, Tsukuba, Ibaraki, Japan, National Institute of Informatics, Tokyo, Japan, Nagoya Sangyo University, 3255-5 Araicho-Yamanota, Owariasahi, Aichi, Japan, Osaka University, 2-1 Yamadaoka, Suita-shi, Osaka, Japan, & Waseda University, 3-4-1 Ohkubo, Shinjuku-ku, Tokyo, Japan. (2012). Analysis of Key Success Factors for Eco-Business Through Case Studies in Japan. International Journal of Automation Technology, 6(3), 252–263.

Kopp, P. (2009). La contribution des deux roues motorisés à la mobilité dans une grande métropole: Le cas de Paris. Transports, 456, 216–229.

Kristinsdóttir, S. Ó. (2012). A bicycle friendly city, a possibility or a dream? An analysis of the bicycle's status and possibilities as transportation in the city of Reykjavík, Iceland. Lunds University.

Krizek, K. J., & Stonebraker, E. W. (2010). Bicycling and Transit: A Marriage Unrealized. Transportation Research Record: Journal of the Transportation Research Board, 2144(1), 161–167.

Krygsman, S., Dijst, M., & Arentze, T. (2004a). Multimodal public transport: An analysis of travel time elements and the interconnectivity ratio. Transport Policy, 11(3), 265–275.

Krygsman, S., Dijst, M., & Arentze, T. (2004b). Multimodal public transport: An analysis of travel time elements and the interconnectivity ratio. Transport Policy, 11(3), 265–275.

Kurosaki, F. (2018). A study of vertical separation in Japanese passenger railways. Case Studies on Transport Policy, 6(3), 391–399.

Kwon, Y.-I., Morichi, S., & Yai, T. (1998). Analysis of Pedestrian Behaviour and Planning Guidelines with Mixed Traffic for Narrow Urban Streets. Transportation Research Record: Journal of the Transportation Research Board, 1636(1), 116–123.

La mise en oeuvre de la réforme ferroviaire, état des lieux du régulateur (p. 44). (2016). ARAFER.

La mobilité en Ile-de-France. (2012). Observatoire de la mobilité en Ile-de-France.

La Paix Puello, L., Olde-Kalter, M.-J., & Geurs, K. T. (2017). Measurement of non-random attrition effects on mobility rates using trip diaries data. Transportation Research Part A: Policy and Practice, 106, 51–64.

Laferrere, G. (2001). Les politiques cyclables en Europe: Tour d'horizon des politiques nationales (p. 77 pages, illustrations) [Report]. Centre d'études sur les réseaux, les transports, l'urbanisme et les constructions publiques (CERTU). https://hal-lara.archives-ouvertes.fr/hal-02150495

Lagadic, M. (2018). Informalité, 違式,意識, le vélo, révélateur d'une régulation informelle de l'espace public au Japon—LAGADIC Marion.pdf. Japarchi, Paris.

Laget, S. (1990). La saga du Tour de France.

Lamming, C. (2003). Paris tram: L'histoire mouvementée du streetcar parisien et des petits trains en Île-de-France. Parigramme.

Landex, A., & Jensen, L. W. (2013). Measures for track complexity and robustness of operation at stations. Journal of Rail Transport Planning & Management, 3(1–2), 22–35.

Lannoy, P. (1999). Un siecle de preoccupations routieres: Regard sociohistorique sur le traitement des problemes engendres par la circulation automobile [a century of concern about roads : a sociohistorical view of the approach to road traffic problems]. Recherche-Transports-Securite. No 65. https://trid.trb.org/view/668614

Lanteri, R., & Doumas, E. (2008). Réseaux de transport ferroviaire privé et effet structurant: Le cas des gares japonaises. Transports urbains, N° 112(1), 19.

Lanzendorf, M., & Busch-Geertsema, A. (2014). The cycling boom in large German cities—Empirical evidence for successful cycling campaigns. Transport Policy, 36, 26–33.

Laroche, P. F. (2014). Economie politique des infrastructures ferroviaires.

Larroque, D. (1989). Apogée, déclin et relance du streetcar en France. 10.

Larsen, Jacob, Patterson, Z., & El-Geneidy, A. (2013). Build It. But Where? The Use of Geographic Information Systems in Identifying Locations for New Cycling Infrastructure. International Journal of Sustainable Transportation, 7(4), 299–317.

Larsen, Jonas. (2017). Bicycle Parking and Locking: Ethnography of Designs and Practices. Mobilities, 12(1), 53–75.

Lavenir, C. B., & Fournel, P. (2011). Voyages à Vélo: Du vélocipède au Vélib'. Paris bibliothèques.

Le bilan des déplacements à Paris en 2015—Mairie de Paris.pdf. (2016). L'observatoire des déplacements à Paris.

Le Blanc, F. (2003). Six classes d'aires urbaines du point de vue des migrations domicile-travail. Six Classes d'aires Urbaines Du Point de Vue Des Migrations Domicile-Travail, 145, 13–20.

Le Breton, E. (2002). Les transports urbains et l'utilisateur: Voyageur, client ou citadin? Editions L'Harmattan.

Le coût réel des déplacements dans m2A Voiture, marche, vélo et transports collectifs (p. 24). (2017). Agence d'urbanisme de la région mulhousienne.

Le marché français du transport ferroviaire de voyageurs 2015-2016 (p. 45). (2018). ARAFER.

Le Néchet, F. (2011). Consommation d'énergie et mobilité quotidienne selon la configuration des densités dans 34 villes européennes. Cybergeo : European Journal of Geography.

Le vélo à assistance électrique: Un nouveau mode de transport métropolitain, données sur l'usage et les usagers du vélo à assistance électrique. (2015). 6-t. https://6-t.co/references/le-velo-a-assistance-electrique-un-nouveau-mode-de-transport-metropolitain/

Leferink, T. S. (2017). Why Cycle To The Railway Station?: A station scanner based on factors that influence bicycle-rail use. With a study on stakeholders in Scotland. https://repository.tudelft.nl/islandora/object/uuid%3A7653ce93-3a2a-4a1f-b804-0b1c4c206eb1

Leger, S. J., Dean, J. L., Edge, S., & Casello, J. M. (2019). "If I had a regular bicycle, I wouldn't be out riding anymore": Perspectives on the potential of e-bikes to support active living and independent mobility among older adults in Waterloo, Canada. Transportation Research Part A: Policy and Practice, 123, 240–254.

Leitzmann, M. F., Park, Y., Blair, A., Ballard-Barbash, R., Mouw, T., Hollenbeck, A. R., & Schatzkin, A. (2007). Physical Activity Recommendations and Decreased Risk of Mortality. Archives of Internal Medicine, 167(22), 2453–2460.

Lemaitre, C. (2014). L'influence des caractéristiques urbaines et de la volonté des décideurs sur la pratique du vélo dans les villes africaines. https://dumas.ccsd.cnrs.fr/dumas-01281668

Les temps de déplacement entre domicile et travail, des disparités selon les horaires de travail (p. 12). (2015). Ministère de la transition écologique et solidaire.

Les transports ferroviaires japonais, la politique d'innovations technologiques dans le contexte de la privatisation. (1998). PREDIT.

Lesens, I. (1998). C'est sérieux, votre histoire de vélo ? Les cahiers de mediologie, N° 5(1), 167–173.

Leth, U., Shibayama, T., & Brezina, T. (2017). Competition or Supplement? Tracing the Relationship of Public Transport and Bike-Sharing in Vienna. GI_Forum, 1, 137–151.

Liao, F., Arentze, T., & Timmermans, H. (2010). Supernetwork Approach for Multimodal and Multiactivity Travel Planning. Transportation Research Record: Journal of the Transportation Research Board, 2175(1), 38–46.

Lichere, V., & Foulon, G. (1999). La modelisation des deplacements intermodaux: Rapport final. DECISION D'AIDE A LA RECHERCHE, 98MT31. https://trid.trb.org/view/956707

Litman, T. (2006). Smart transportation investments: Reevaluating the role of highway expansion for improving urban transportation. https://www.osti.gov/etdeweb/biblio/20818731

Litman, T. A. (2003). Economic Value of Walkability. Transportation Research Record: Journal of the Transportation Research Board, 1828(1), 3–11.

Litman, Todd. (1997). Full cost accounting of urban transportation: Implications and tools. Cities, 14(3), 169–174.

Litman, Todd. (2006). Smart Transportation Investments II: Reevaluating The Role Of Public Transit For Improving Urban Transportation. https://trid.trb.org/view/792777

Litman, Todd. (2007). Developing Indicators for Comprehensive and Sustainable Transport Planning. Transportation Research Record, 2017(1), 10–15.

Litman, Todd. (2008). Valuing transit service quality improvements. Journal of Public Transportation, 11(2).

Liu, X., Huang, Y., Xu, X., Li, X., Li, X., Ciais, P., Lin, P., Gong, K., Ziegler, A. D., Chen, A., Gong, P., Chen, J., Hu, G., Chen, Y., Wang, S., Wu, Q., Huang, K., Estes, L., & Zeng, Z. (2020). High-spatiotemporal-resolution mapping of global urban change from 1985 to 2015. Nature Sustainability, 3(7), 564–570.

Longhurst, J. (2015). Bike battles: A history of sharing the American road. University of Washington Press.

Loo, B. P. Y. (2018). Realising car-free developments within compact cities. Proceedings of the Institution of Civil Engineers - Municipal Engineer, 171(1), 41–50.

Lopez-Ruiz, H. G., & Crozet, Y. (2011). La voie étroite du " facteur 4 " dans le secteur des transports: Quelles politiques publiques, pour quelles mobilités ? Recherche Transports Sécurité - RTS, 27(1), 54–73.

Lourontzi, E., & Petachti, S. (2017). Cycling: Utilitarian and symbolic dimensions. Transportation Research Procedia, 24, 137–145.

Lovelace, R., Beck, S. B. M., Watson, M., & Wild, A. (2011). Assessing the energy implications of replacing car trips with bicycle trips in Sheffield, UK. Energy Policy, 39(4), 2075–2087.

Lowe, M. D. (1989). The bicycle: Vehicle for a small planet. https://trid.trb.org/view/303655

Lowry, M. B., Furth, P., & Hadden-Loh, T. (2016). Prioritizing new bicycle facilities to improve low-stress network connectivity. Transportation Research Part A: Policy and Practice, 86, 124–140.

Ma, L., & Dill, J. (2015). Associations between the objective and perceived built environment and bicycling for transportation. Journal of Transport & Health, 2(2), 248–255.

Ma, L., & Ye, R. (2019). Does daily commuting behaviour matter to employee productivity? Journal of Transport Geography, 76, 130–141.

MacKay, D. (2008). Sustainable Energy—Without the hot air. UIT Cambridge.

Macmillan, A., Connor, J., Witten, K., Kearns, R., Rees, D., & Woodward, A. (2014). The Societal Costs and Benefits of Commuter Bicycling: Simulating the Effects of Specific Policies Using System Dynamics Modeling. Environmental Health Perspectives, 122(4), 335–344.

Mannisto-Funk, T., & Myllyntaus, T. (Eds.). (2019). Invisible bicycle: Parallel histories and different timelines. Brill.

Margail, F. (1996). Les parcs relais, outils clés de politiques intermodales de déplacement urbain [Phdthesis, Ecole Nationale des Ponts et Chaussées]. https://pastel.archives-ouvertes.fr/tel-00529491

Marmignon, P. (2007). Seki Hajime (1873-1935) contre une tradition nippone urbaphobe. 16.

Marquet, C. (2016). Des services connectés pour améliorer l'accessibilité des gares ? Espace Populations Sociétés, 2016(2). https://halshs.archives-ouvertes.fr/halshs-01348005

Martens, K. (2004). The bicycle as a feedering mode: Experiences from three European countries. Transportation Research Part D: Transport and Environment, 9(4), 281–294.

Martens, K. (2007). Promoting bike-and-ride: The Dutch experience. Transportation Research Part A: Policy and Practice, 41(4), 326–338.

Martial, L. (2010). Une nouvelle définition de la gare Montparnasse. Ecole spéciale d'architecture.

Masai, Y. (1990). Tokyo: From A Feudal Million City To A Global Supercity. Geographical Review of Japan, Series B., 63(1), 1–16.

Masiol, M., Agostinelli, C., Formenton, G., Tarabotti, E., & Pavoni, B. (2014). Thirteen years of air pollution hourly monitoring in a large city: Potential sources, trends, cycles and effects of car-free days. Science of The Total Environment, 494–495, 84–96.

Masiol, M., Squizzato, S., Ceccato, D., & Pavoni, B. (2015). The size distribution of chemical elements of atmospheric aerosol at a semi-rural coastal site in Venice (Italy). The role of atmospheric circulation. Chemosphere, 119, 400–406.

Massot, M.-, & Armoogum, J. (2002). Evaluating the potential for reducing car traffic in the dense part of the Greater Paris Region. Recherche - Transports - Securite (French), 77. https://trid.trb.org/view/1210765

Massot, M.-H., Armoogum, J., Bonnel, P., & Caubel, D. (2004). Une ville sans voiture: Utopie ? Revue d'Économie Régionale & Urbaine, décembre(5), 753.

Massot, M.-H., Orfeuil, J., & Proulhac, L. (2013). A la recherche d'un marché pour un petit véhicule urbain en Ile-de-France, rapport final de contrat pour l'Ademe, février. [Report]. https://hal.archives-ouvertes.fr/hal-00852113

Massot, M.-H., & Orfeuil, J.-P. (2005). La mobilité au quotidien, entre choix individuel et production sociale. Cahiers internationaux de sociologie, n° 118(1), 81–100.

Massot, M.-H., & Orfeuil, J.-P. (2007). La contrainte énergétique doit-elle réguler la ville ou les véhicules ? Mobilités urbaines et réalisme écologique. Les Annales de la Recherche Urbaine, 103(1), 18–29.

Masuch, N., Lützenberger, M., & Keiser, J. (2013). An Open Extensible Platform for Intermodal Mobility Assistance. Procedia Computer Science, 19, 396–403.

Mateo-Babiano, I., Ieda, H., & Eng, D. (2005). Street space renaissance: A spatio-historical survey of two asian cities. 6, 16.

Mateo-Babiano, I., Kumar, S., & Mejia, A. (2017). Bicycle sharing in Asia: A stakeholder perception and possible futures. Transportation Research Procedia, 25, 4966–4978.

Mathon, P., & Plamier, P. (2012). Vélo et politique globale de mobilité durable. Comment Estimer Le Potentiel Cyclable d'un Territoire? Une Application Sur l'agglomération Lilloise.

Mátrai, T., & Tóth, J. (2016). Comparative Assessment of Public Bike Sharing Systems. Transportation Research Procedia, 14, 2344–2351.

Matsui, Y., Oikawa, S., & Hitosugi, M. (2015). Characteristics of approach pattern in car and bicycle in Japanese traffic road. Journal of Local and Global Health Science, 2015(2), 13.

Matsui, Y., Oikawa, S., & Hitosugi, M. (2016). Analysis of car-to-bicycle approach patterns for developing active safety devices. Traffic Injury Prevention, 17(4), 434–439.

Mayeres, I., Ochelen, S., & Proost, S. (1996). The marginal external costs of urban transport. Transportation Research Part D-Transport and Environment, 1(2), 111–130.

McCahill, C., & Garrick, N. (2012). Automobile use and land consumption: Empirical evidence from 12 cities. URBAN DESIGN International, 17(3), 221–227.

McDonald, J. F., d'Ouville, E. L., & Liu, L. N. (1999). Economics of Urban Highway Congestion and Pricing. Springer US.

McDonald, S. S. (2009). Sustainability, PRT, and Parking. Automated People Movers 2009, 297–308.

Melia, S. (2010, October). Carfree, low-car: What's the difference? European Transport Conference, 2010, Glasgow, Scotland, United Kingdom. https://trid.trb.org/view/1148599

Menerault, P., Barré, A., Conesa, A., l'Hostis, A., Pucci, P., & Stranski, V. (2006). Multipolarités urbaines et nouvelles organisations intermodales. 126p.

Merger, M. (2006). Intermodality, Historians and Policy Making in Europe: Finalising a Successful Research Project. The Journal of Transport History, 27(1), 150–154.

Mertens, L., Compernolle, S., Deforche, B., Mackenbach, J. D., Lakerveld, J., Brug, J., Roda, C., Feuillet, T., Oppert, J.-M., Glonti, K., Rutter, H., Bardos, H., De Bourdeaudhuij, I., & Van Dyck, D. (2017). Built environmental correlates of cycling for transport across Europe. Health & Place, 44, 35–42.

Mesmer, P., & Maurisse, M. (2018, April 21). Le Japon et la Suisse, ces deux pays où les trains partent et arrivent à l'heure. Le Monde.fr. https://www.lemonde.fr/economie/article/2018/04/21/le-japon-et-la-suisse-ces-deux-pays-ou-les-trains-partent-et-arrivent-a-l-heure_5288608_3234.html

Meyer, M., & Miller, E. J. (2001). Urban Transportation Planning: A Decision-oriented Approach. McGraw-Hill.

Michaud, V. (2007). 2001-2007: Extension du domaine du vélo. Transports Urbains, 2, 3–5.

Midenet, S., Côme, E., & Papon, F. (2018). Modal shift potential of improvements in cycle access to exurban train stations. Case Studies on Transport Policy, 6(4), 743–752.

Mikesell, R. F. (University of O. (USA)). (1992). Economic development and the environment a comparison of sustainable development with conventional development economics. Mansell Publishing Ltd. https://agris.fao.org/agris-search/search.do?recordID=GB9137427

Millard-Ball, A. (2019). The autonomous vehicle parking problem. Transport Policy, 75, 99–108.

Miller, G. W. (2015). Car Crazy: The Battle for Supremacy between Ford and Olds and the Dawn of the Automobile Age (Illustrated edition). PublicAffairs.

Mills, G., & White, P. (2018). Evaluating the long-term impacts of bus-based park and ride. Research in Transportation Economics, 69, 536–543.

Minet, L., Stokes, J., Scott, J., Xu, J., Weichenthal, S., & Hatzopoulou, M. (2018). Should traffic-related air pollution and noise be considered when designing urban bicycle networks? Transportation Research Part D: Transport and Environment, 65, 736–749.

Mingardo, G. (2013). Transport and environmental effects of rail-based Park and Ride: Evidence from the Netherlands. Journal of Transport Geography, 30, 7–16.

Mingardo, G., van Wee, B., & Rye, T. (2015). Urban parking policy in Europe: A conceptualization of past and possible future trends. Transportation Research Part A: Policy and Practice, 74, 268–281.

Minh, N. Q. (2016). Application of "Car-Free City" and "City of Short Walks" to Living Quarters in Hanoi Towards Sustainable Mobility and Logistics. Procedia Engineering, 142, 284–291.

Mishra, S., Welch, T. F., & Jha, M. K. (2012). Performance indicators for public transit connectivity in multi-modal transportation networks. Transportation Research Part A: Policy and Practice, 46(7), 1066–1085.

Mitchell†, A. (2000). The Great Train Race: Railways and the Franco-German Rivalry, 1815-1914. Berghahn Books.

Mitchell, D. H., & MacGregor Smith, J. (2001). Topological network design of pedestrian networks. Transportation Research Part B: Methodological, 35(2), 107–135.

Mitchell, W. J., Borroni-Bird, C., & Burns, L. D. (2010). Reinventing the automobile: Personal urban mobility for the 21st century. Massachusetts Institute of Technology.

Mohajeri, N., & Amin, G. R. (2010). Railway station site selection using analytical hierarchy process and data envelopment analysis. Computers & Industrial Engineering, 59(1), 107–114.

Mohanty, S., Bansal, S., & Bairwa, K. (2017). Effect of integration of bicyclists and pedestrians with transit in New Delhi. Transport Policy, 57, 31–40.

Molin, E., & Maat, K. (2015). Bicycle parking demand at railway stations: Capturing price-walking trade offs. Research in Transportation Economics, 53, 3–12.

Mom, G. (2004). Inter-artifactual Technology Transfer: Road Building Technology in the Netherlands and the Competition Between Bricks, Macadam, Asphalt and Concrete. History and Technology, 20(1), 75–96.

Mom, G. (2007). Mobility for pleasure: A look at the underisde of Dutch diffusion curves (1920-1940). Tst: Transportes, Servicios y Telecomunicaciones, 12, 30–68.

Mom, G. (2009). Compétition et coexistence: La motorisation des transports terrestres et le lent processus de substitution de la traction équine. Le Mouvement Social, n° 229(4), 13–39.

Mom, G.P.A., Zeilinger, S., Algemene Wetenschappen, & The Development of Technology in The Netherlands in the Twentieth Century. (2003). Conceptualising technical change: Alternative interaction in the evolution of the automobile. In Tackling Transport (pp. 9–46). Science Museum. https://research.tue.nl/nl/publications/conceptualising-technical-change-alternative-interaction-in-the-evolution-of-the-automobile(2021e2e4-5b13-42f2-b630-3bf145b57de5).html

Monheim, H., & Monheim-Dandorfer, R. (1990). Strassen fuer alle—Analysen und konzepte zum stadtverkehr der zukunft. https://trid.trb.org/view/1013943

Montialoux, C. (2009). La valeur tutélaire du carbone. Regards croises sur l'economie, n° 6(2), 132–134.

Monzón, A., Hernández, S., & Di Ciommo, F. (2016). Efficient Urban Interchanges: The City-HUB Model. Transportation Research Procedia, 14, 1124–1133.

Moody, S., & Melia, S. (2014). Shared space – research, policy and problems. Proceedings of the Institution of Civil Engineers - Transport, 167(6), 384–392.

Mori, C. (2013). Esquisse d'une sociologie des banlieues au Japon. Hommes & migrations, 1302, 45–55.

Morishige, S., Sano, K., & Nishiuchi, H. (2014). Evaluation on bicycle removal policies by considering bicycle parking behaviour and willingness pay by residents. Journal of Japan Society of Civil Engineers, Ser. D3 (Infrastructure Planning and Management), 70(5), 849–858.

Moyano, A., & Dobruszkes, F. (2017). Mind the services! High-speed rail cities bypassed by high-speed trains. Case Studies on Transport Policy, 5(4), 537–548.

Muñoz, B., Monzon, A., & López, E. (2016). Transition to a cyclable city: Latent variables affecting bicycle commuting. Transportation Research Part A: Policy and Practice, 84, 4–17.

Muromachi, Y., Harata, N., & Ohta, K. (2000). A Study on the Social Cost of Regulation and Enforcement. Infrastructure Planning Review, 17, 863–868.

Nakahara, S., Ichikawa, M., & Kimura, A. (2011). Population strategies and high-risk-individual strategies for road safety in Japan. Health Policy, 100(2–3), 247–255.

Nakamura, F. (2014). Role of connected mobility concept for twenty-first-century cities—Trial approach for conceptualization of connected mobility through case studies. IATSS Research, 38(1), 52–57.

Nakamura, H., & Abe, N. (2014a). Evaluation of the hybrid model of public bicycle-sharing operation and private bicycle parking management. Transport Policy, 35, 31–41.

Nakamura, H., & Abe, N. (2014b). The role of a non-profit organisation-run public bicycle-sharing programme: The case of Kitakyushu City, Japan. Journal of Transport Geography, 41, 338–345.

Nash, C. (2008). Passenger railway reform in the last 20 years – European experience reconsidered. Research in Transportation Economics, 22(1), 61–70.

Nash, C. (2010). European rail reform and passenger services – the next steps. Research in Transportation Economics, 29(1), 204–211.

Nelson, A. C., & Allen, D. (1997). If You Build Them, Commuters Will Use Them: Association Between Bicycle Facilities and Bicycle Commuting. Transportation Research Record, 1578(1), 79–83.

Newman, P., Beatley, T., & Boyer, H. (2009). Resilient Cities: Responding to Peak Oil and Climate Change. Island Press.

Newman, P., & Kenworthy, J. (2015). The End of Automobile Dependence: In The End of Automobile Dependence: How Cities Are Moving Beyond Car-Based Planning (pp. 201–226). Island Press/Center for Resource Economics.

Newman, P. W. G., & Kenworthy, J. R. (1989). Gasoline Consumption and Cities: A Comparison of U.S. Cities with a Global Survey. Journal of the American Planning Association, 55(1), 24–37.

Nguyen-Phuoc, D. Q., Currie, G., De Gruyter, C., & Young, W. (2018). How do public transport users adjust their travel behaviour if public transport ceases? A qualitative study. Transportation Research Part F: Traffic Psychology and Behaviour, 54, 1–14.

Nicolas, B. (2007). Le Machizukuri au Japon, naissance et evolution d'un concept vernaculaire de l'urbanisme. The Economic review of Toyo University, 32(2), 13–20.

Niel, X. (1998). Pourquoi se passer de sa voiture ? 4.

Nielsen, T. A. S., Olafsson, A. S., Carstensen, T. A., & Skov-Petersen, H. (2013). Environmental correlates of cycling: Evaluating urban form and location effects based on Danish micro-data. Transportation Research Part D: Transport and Environment, 22, 40–44.

Nieuwenhuijsen, M. J., & Khreis, H. (2016). Car free cities: Pathway to healthy urban living. Environment International, 94, 251–262.

Nishikawa, K., & Yamamoto, S. (2011). Research on Shared Space, part1. Proceedings of the Annual Conference of Jssd, 58, 66–66.

Nourian, P., Rezvani, S., Valeckaite, K., & Sariyildiz, S. (2018). Modelling walking and cycling accessibility and mobility: The effect of network configuration and occupancy on spatial dynamics of active mobility. Smart and Sustainable Built Environment, 7(1), 101–116.

O'Brien, O., Cheshire, J., & Batty, M. (2014). Mining bicycle sharing data for generating insights into sustainable transport systems. Journal of Transport Geography, 34, 262–273.

Offner, J.-M. (1988). La disparition des streetcars en France. Chemins de Fer, 388, 6–10.

Oguchi, T. (2016). Achieving safe road traffic—The experience in Japan. IATSS Research, 39(2), 110–116.

Ohno, H. (2006). Tokyo 2050 Fibercity. JA, 63, 1–135.

Ohno, H. (2016). Fiber city: A vision for cities in the age of shrinkage. University of Tokyo Press.

Okeil, A. (2010). A holistic approach to energy efficient building forms. Energy and Buildings, 42(9), 1437–1444.

Olafsson, A. S., Nielsen, T. S., & Carstensen, T. A. (2016). Cycling in multimodal transport behaviours: Exploring modality styles in the Danish population. Journal of Transport Geography, 52, 123–130.

Olaru, D., Smith, B., Xia, J. (Cecilia), & Lin, T. (Grace). (2014). Travellers' Attitudes Towards Park-and-Ride (PnR) and Choice of PnR Station: Evidence from Perth, Western Australia. Procedia - Social and Behavioural Sciences, 162, 101–110.

Oldenziel, R., & Albert de la Bruhèze, A. (2011). Contested Spaces. Transfers, 1(2), 29–49.

Oldenziel, R., & de la Bruhèze, A. A. (2012). Cycling in a Global World. Transfers, 2(2), 22–30.

Oliveira, G. N., Sotomayor, J. L., Torchelsen, R. P., Silva, C. T., & Comba, J. L. D. (2016). Visual analysis of bike-sharing systems. Computers & Graphics, 60, 119–129.

Oosterhuis, H. (2014). Bicycle Research between Bicycle Policies and Bicycle Culture. Mobility in History, 5(1).

Oosterhuis, H. (2016). Cycling, modernity and national culture. Social History, 41(3), 233–248.

Orfeuil, J.-P. (1996). Transports et effet de serre. Transports et Effet de Serre, 79, 44–49.

Orfeuil, J.-P. (2004a). Accessibilité, mobilité, inegalités: Regards sur la question en france aujourd'hui. 26.

Orfeuil, J.-P. (2004b). Accessibilité, mobilité, inégalités: Regards sur la question en France aujourd'hui. Transports, Pauvretés, Exclusions: Pouvoir Bouger Pour s' En Sortir, París, Éditions de l'Aube.

Orfeuil, J.-P., Bieber, A., Lefol, J. F., Troulay, P., Massot, M.-H., Monjaret, B., HIVERT, L., Potier, F., CHRISTINE, M., & Chaigneau, E. (1989). Un milliard de déplacements par semaine. La mobilité des français.

Orselli, J. (2011). Usages et usagers de la route: Requiem pour un million de morts: 1860-2010. Editions L'Harmattan.

Pal, A., & Zhang, Y. (2017). Free-floating bike sharing: Solving real-life large-scale static rebalancing problems. Transportation Research Part C: Emerging Technologies, 80, 92–116.

Papa, E., & Bertolini, L. (2015). Accessibility and Transit-Oriented Development in European metropolitan areas. Journal of Transport Geography, 47, 70–83.

PAPON, F. (1997). Les modes oubliés: Marche, bicyclette, cyclomoteur, motocyclette. Les Modes Oubliés : Marche, Bicyclette, Cyclomoteur, Motocyclette, 56, 61–75.

Papon, F. (1999). La marche et la bicyclette dans les enquetes transport aupres des menages. Compte rendu final. RAPPORT DE CONVENTION MINISTERE DE L'AMENAGEMENT DU TERRITOIRE ET DE L'ENVIRONNEMENT. PROGRAMMATION SRAE/BCRD 98. SUBVENTION N.98146. https://trid.trb.org/view/959525

Papon, F. (2001a). Evolution de la mobilite dans le monde: Quelle place pour la bicyclette ? VELOCITE, 63. https://trid.trb.org/view/956177

Papon, F. (2001b). Perspectives de la mobilite urbaine. Apres la transition vers l'automobile sur le modele americain, l'Europe cherche un nouvel equilibre multimodal. COLLOQUE CROISSANCE URBAINE,MODES DE TRANSPORT ET INTERMODALITE, CHENGDU, CHINE, 29-30 OCTOBRE 2001. https://trid.trb.org/view/956174

Papon, F., Armoogum, J., Madre, J. L., & Massot, M. H. (2001). Prospective de la mobilite en Ile-de-France: Les apports et les limites d'une demarche econometrique. https://trid.trb.org/view/956323

Papon, F., Beauvais, J. M., Midenet, S., Côme, E., Polombo, N., Abours, S., Belton-Chevallier, L., & Soulas, C. (2017). Evaluation of the bicycle as a feeder mode to regional train stations. Transportation Research Procedia, 25, 2717–2736.

Papon, Francis. (2002a). La marche et le vélo: Quels bilans économiques pour l'individu et la collectivité? Première partie: le temps et l'argent. Transports, 412.

Papon, Francis. (2002b). Mûrissement social et pratique de la bicyclette. 31.

Papon, Francis. (2010). Le vélo représente 2, 7% des déplacements en semaine. Vélocité.

Papon, Francis. (2012). Le retour du vélo comme mode de déplacement [Thesis, UNIVERSITE PARIS-EST]. https://tel.archives-ouvertes.fr/tel-00852427

Papon, Francis. (2011). L'évolution de la mobilité à vélo en France. 19p. https://hal.archives-ouvertes.fr/hal-00909017

Papon, Francis, Chevallier, L. B., Abours, S., Come, E., Midenet, S., Soulas, C., Beauvais, J. M., & Polombo, N. (2012). L'intermodalité vélo-train: Une évaluation socio-économique des bénéfices. 5.

Papon, Francis, Chevallier, L. B., Abours, S., Come, E., Midenet, S., Soulas, C., Beauvais, J. M., & Polombo, N. (2015). Rapport final du projet VERT. Le vélo évalué en rabattement dans les territoires. Volume 1. 104.

Papon, Francis, & De Solère, R. (2010). Les modes actifs: Marche et vélo de retour en ville. La Revue, Commissariat Général Au Développement Durable-Service de l'observation et Des Statistiques.

Papon, Francis, & Dusong, C. (2016). Bilan positif de la pratique du vélo—Santé et environnement. 20.

Pappalardo, M., Armoogum, J., Hubert, J.-P., Roux, S., Paris-Est, P., Jeannic, T. L., Quételard, B., Nord-Picardie, C., Papon, F., de Solère, R., François, D., Robin, M., Grimal, R., Bouffard-Savary, E., Longuar, Z., Nicolas, J.-P., Verry, D., Caenen, Y., Île-de-France, I., … Siméon, T. (2010a). La mobilité des Français Panorama issu de l'enquête nationale transports et déplacements 2008. 228.

Pappalardo, M., Armoogum, J., Hubert, J.-P., Roux, S., Paris-Est, P., Jeannic, T. L., Quételard, B., Nord-Picardie, C., Papon, F., de Solère, R., François, D., Robin, M., Grimal, R., Bouffard-Savary, E., Longuar, Z., Nicolas, J.-P., Verry, D., Caenen, Y., Île-de-France, I., … Siméon, T. (2010b). La mobilité des Français Panorama issu de l'enquête nationale transports et déplacements 2008. 228.

Paquot, T. (2009). La bicyclette urbaine: Histoire et représentations. Urbanisme, 366, 45–50.

Parkes, S. D., Marsden, G., Shaheen, S. A., & Cohen, A. P. (2013). Understanding the diffusion of public bikesharing systems: Evidence from Europe and North America. Journal of Transport Geography, 31, 94–103.

Paul-Dubois-Taine, O. (2010). Les nouvelles mobilités, adapter l'automobile aux modes de vie de demain. http://temis.documentation.developpement-durable.gouv.fr/docs/Temis/0068/Temis-0068188/18947_Rapport.pdf

Pelzer, P. (2010). Bicycling as a Way of Life: A Comparative Case Study of Bicycle Culture in Portland, OR and Amsterdam. 14.

Peng, J., Peng, F.-L., Yabuki, N., & Fukuda, T. (2019). Factors in the development of urban underground space surrounding metro stations: A case study of Osaka, Japan. Tunnelling and Underground Space Technology, 91, 13.

Perennes, P. (2014). Spécificité du secteur ferroviaire et libéralisation: La question du signal prix. Université Paris 1 Pantheon-Sorbonne.

Perri, P. (2009). SNCF, un scandale français: Retards, emplois détruits, manque à gagner, dette secrète, subventions déguisées. Eyrolles.

Perrin, E. (2010). Les parcs relais urbains: Étude bibliographique 2010 (p. 157 pages, illustrations, carte, bibliographie) [Report]. Centre d'études sur les réseaux, les transports, l'urbanisme et les constructions publiques (CERTU). https://hal-lara.archives-ouvertes.fr/hal-02150448

Pham, C. (2014). Smart cities in Japan: An assessment on the potential for EU-Japan cooperation and business development (p. 67).

Piatkowski, D. P., & Marshall, W. E. (2015). Not all prospective bicyclists are created equal: The role of attitudes, socio-demographics, and the built environment in bicycle commuting. Travel Behaviour and Society, 2(3), 166–173.

Piednoir, F. (2007). Pédaler intelligent: La biomécanique du cycliste. Fédération française de cyclotourisme.

Pinon, P. (2002). Atlas du Paris haussmannien: La ville en héritage du Second Empire à nos jours. Parigramme.

Pitsiava-Latinopoulou, M., & Iordanopoulos, P. (2012). Intermodal Passengers Terminals: Design Standards for Better Level of Service. Procedia - Social and Behavioural Sciences, 48, 3297–3306.

Plazier, P. A., Weitkamp, G., & van den Berg, A. E. (2017). "Cycling was never so easy!" An analysis of e-bike commuters' motives, travel behaviour and experiences using GPS-tracking and interviews. Journal of Transport Geography, 65, 25–34.

Pooley, C. G., Horton, D., Scheldeman, G., Mullen, C., Jones, T., Tight, M., Jopson, A., & Chisholm, A. (2013). Policies for promoting walking and cycling in England: A view from the street. Transport Policy, 27, 66–72.

Pooley, C. G., & Turnbull, J. (2000). Modal choice and modal change: The journey to work in Britain since 1890. Journal of Transport Geography, 8(1), 11–24.

Portable bicycle parking system—Mobile eco-system. (2016).

Portland State University, Dill, J., & Gliebe, J. (2008). Understanding and Measuring Bicycling Behaviour: A Focus on Travel Time and Route Choice. Portland State University Library.

Poulit, J. (2005). Le territoire des hommes. La création de richesse, d'emplois et de bien-être au sein d'une planète préservée—Jean Poulit. https://www.decitre.fr/livres/le-territoire-des-hommes-9782849410028.html

Praznoczy, C. (2012). Les bénéfices et les risques de la pratique du vélo—Évaluation en Ile-de-France. Pollution Atmosphérique, 4, 57.

Praznoczy, C. (2013). Les avantages sanitaires de la pratique du vélo dans le cadre des déplacements domicile-travail (p. 36). Ministère de l'Écologie, du Développement durable et de l'Énergie.

Priemus, H., & Konings, R. (2001). Light rail in urban regions: What Dutch policymakers could learn from experiences in France, Germany and Japan. Journal of Transport Geography, 9(3), 187–198.

Prud'Homme, R., Kopp, P., & Bocarejo, J. P. (2005). Evaluation économique de la politique parisienne des transports. Revue Transports, Nov-décembre(434), 346–359.

Prud'homme, R., & Lee, C.-W. (1999). Size, Sprawl, Speed and the Efficiency of Cities. Urban Studies, 36(11), 1849–1858.

Publications, W. B. (2014). Turn Down the Heat: Confronting the New Climate Normal. World Bank Publications.

Pucher, J. (1988). Urban travel behaviour as the outcome of public policy: The example of modal-split in Western Europe and North America. Journal of the American Planning Association, 54(4), 509–520.

Pucher, J., & Buehler, R. (2008). Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany. Transport Reviews, 28(4), 495–528.

Pucher, J., & Buehler, R. (2009). Integrating Bicycling and Public Transport in North America. Journal of Public Transportation, 12(3), 79–104.

Pucher, J., & Buehler, R. (2017). Cycling towards a more sustainable transport future. Transport Reviews, 37(6), 689–694.

Pucher, J., Buehler, R., & Seinen, M. (2011). Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies. Transportation Research Part A: Policy and Practice, 45(6), 451–475.

Pucher, J., Dill, J., & Handy, S. (2010). Infrastructure, programs, and policies to increase bicycling: An international review. Preventive Medicine, 50, 106–125.

Pucher, J. R., & Lefèvre, C. (1996). The urban transport crisis in Europe and North America. Macmillan.

Puello, L. C. L. P., & Geurs, K. T. (2014, June 24). Adaptive stated choice experiment for access and egress mode choice to train stations. Proceedings of the WSTLUR, 24-27-June 2014 Delft. World Symposium on Transport and Land Use Research 2014. https://research.utwente.nl/en/publications/adaptive-stated-choice-experiment-for-access-and-egress-mode-choi

Qin, H., Gao, J., Kluger, R., & Wu, Y.-J. (2018). Effects of perception on public bike-and-ride: A survey under complex, multifactor mode-choice scenarios. Transportation Research Part F: Traffic Psychology and Behaviour, 54, 264–275.

Qin, H., Guan, H., & Wu, Y.-J. (2013). Analysis of park-and-ride decision behaviour based on Decision Field Theory. Transportation Research Part F: Traffic Psychology and Behaviour, 18, 199–212.

Quarmby, D. A. (1967). Choice of Travel Mode for the Journey to Work: Some Findings. Journal of Transport Economics and Policy, 1(3), 273–314.

Quinet, E. (2000). Evaluation methodologies of transportation projects in france. Transport Policy, 7(1). https://trid.trb.org/view/659611

Quinet, E. (2005). Peut-on se fier aux calculs de couts externes ? Transports, N429. https://trid.trb.org/view/945260

Rabl, A., & de Nazelle, A. (2012). Benefits of shift from car to active transport. Transport Policy, 19(1), 121–131.

Rachline, F. (2008). Le vélo du baron. L'Economie politique, n°38(2), 101–106.

Randriamanamihaga, A. N., Côme, E., Oukhellou, L., & Govaert, G. (2014). Clustering the Vélib′ dynamic Origin/Destination flows using a family of Poisson mixture models. Neurocomputing, 141, 124–138.

Raux, C., Zoubir, A., & Geyik, M. (2017). Who are bike sharing schemes members and do they travel differently? The case of Lyon's "Velo'v" scheme. Transportation Research Part A: Policy and Practice, 106, 350–363.

Ravalet, E., & Bussière, Y. (2012). Les systèmes de vélos en libre-service expliquent-ils le retour du vélo en ville ? Recherche Transports Sécurité, 28(1), 15–24.

Ravensbergen, L., Buliung, R., Mendonca, M., & Garg, N. (2018). Biking to Ride: Investigating the Challenges and Barriers of Integrating Cycling with Regional Rail Transit. Transportation Research Record: Journal of the Transportation Research Board, 2672(8), 374–383.

Razemon, O. (2014). Le pouvoir de la pédale. Comment Le Vélo Transforme Nos Sociétés Cabossées. Rue Échiquier, Collection Les Petits Ruis, Paris.

Reghezza-Zitt, M., & Rufat, S. (2016). Resilience Imperative: Uncertainty, risks and disasters.

Reid, C. (2015). Roads Were Not Built for Cars: How cyclists were the first to push for good roads & became the pioneers of motoring. Island Press.

Reiss, S., & Bogenberger, K. (2016). Validation of a Relocation Strategy for Munich's Bike Sharing System. Transportation Research Procedia, 19, 341–349.

Replogle, M. (1992). Bicycle Access to Public Transportation: Learning from Abroad. Transportation Research Record, 6.

Rérat, P. (2019). Cycling to work: Meanings and experiences of a sustainable practice. Transportation Research Part A: Policy and Practice, 123, 91–104.

Reverdy, G. (1986). Atlas historique des routes de France. https://trid.trb.org/view/1020320

Ribeill, G. (1985). Aspects du développement du réseau ferré français sur la longue durée. L'approche historique. Cahier / Groupe Réseaux, 1(1), 10–25.

Richards, B. (2012). Future Transport in Cities. Taylor & Francis.

Richards, D. C. (2010). Relationship between Speed and Risk of Fatal Injury: Pedestrians and Car Occupants (p. 41). Department for Transport : London.

Richardson, A. J., Ampt, E. S., & Meyburg, A. H. (1995). Survey Methods for Transport Planning.

Richardson, T., & Jensen, O. B. (2003). Linking Discourse and Space: Towards a Cultural Sociology of Space in Analysing Spatial Policy Discourses. Urban Studies, 40(1), 7–22.

Richer, C. (2007a). Quelles politiques intermodales dans la planification territoriale ? Flux, n° 69(3), 35–48.

Richer, C. (2007b). Multipolarités urbaines et intermodalité: Les pôles d'échanges, un enjeu pour la coopération intercommunale ? [Phdthesis, Université des Sciences et Technologie de Lille - Lille I]. https://tel.archives-ouvertes.fr/tel-00260379

Richer, C. (2008). L'émergence de la notion de pôle d'échanges, entre interconnexion des réseaux et structuration des territoires. Les Cahiers scientifiques du transport, n°54, 101–123.

Ricroch, L. (2016). Les comptes des transports en 2016—Tome 1 (p. 196). Ministère de la transition écologique et solidaire.

Rietveld, P. (2000). The accessibility of railway stations: The role of the bicycle in The Netherlands. Transportation Research Part D: Transport and Environment, 5(1), 71–75.

Rietveld, P., & Daniel, V. (2004). Determinants of bicycle use: Do municipal policies matter? Transportation Research Part A: Policy and Practice, 38(7), 531–550.

Riot, E. (2016). L'agencement des grandes gares historiques pour le marché ferroviaire européen: Analyse comparée de l'intégration des principes concurrentiels dans l'aménagement et la gestion des gares de London St Pancras, Paris Nord et Milano Centrale. École Nationale des Ponts et Chaussées.

Risser, R. (1985). Behaviour in traffic conflict situations. Accident Analysis & Prevention, 17(2), 179–197.

Robert, M. (2005). Pour en finir avec la société de l'automobile (p. 53). CarFree France.

Robinson, D. L. (2006). No clear evidence from countries that have enforced the wearing of helmets. Bmj, 332(7543), 722–725.

Rodrigue, J.-P., Comtois, C., & Slack, B. (2017). The geography of transport systems (4th edition). Routledge, Taylor & Francis Group.

Rodriguez-Iturbe, I., Marani, M., Rigon, R., & Rinaldo, A. (1994). Self-organized river basin landscapes: Fractal and multifractal characteristics. Water Resources Research, 30(12), 3531–3539.

Rojas-Rueda, D., de Nazelle, A., Tainio, M., & Nieuwenhuijsen, M. J. (2011). The health risks and benefits of cycling in urban environments compared with car use: Health impact assessment study. Bmj, 343.

Rose, J. (1999). New York city bicycle parking needs (p. 148). City of New York, Department of City Planning, Transportation Division.

Roson, R., & Soriani, S. (2000). Intermodality and the changing role of nodes in transport networks. Transportation Planning and Technology, 23(3), 183–197.

Roty, T. (1996). Eki (le relais). La gare au Japon. Les Annales de la recherche urbaine, 71(1), 75–85.

Roughgarden, T. (2005). Selfish Routing and the Price of Anarchy.

Roughgarden, T., & Tardos, E. (2001). How Bad is Selfish Routing? 26.

Rybarczyk, G., & Wu, C. (2010). Bicycle facility planning using GIS and multi-criteria decision analysis. Applied Geography, 30(2), 282–293.

Saberi, M., Ghamami, M., Gu, Y., Shojaei, M. H. (Sam), & Fishman, E. (2018). Understanding the impacts of a public transit disruption on bicycle sharing mobility patterns: A case of Tube strike in London. Journal of Transport Geography, 66, 154–166.

Saghapour, T., Moridpour, S., & Thompson, R. G. (2016). Public transport accessibility in metropolitan areas: A new approach incorporating population density. Journal of Transport Geography, 54, 273–285.

Sakai, A. (2015). Non-rail business. New ways of financing public transportation.

Sakakibara, Y. (2012). Social change and future transport policy in the Japanese context. IATSS Research, 35(2), 56–61.

Sallis, J. F., Conway, T. L., Dillon, L. I., Frank, L. D., Adams, M. A., Cain, K. L., & Saelens, B. E. (2013). Environmental and demographic correlates of bicycling. Preventive Medicine, 57(5), 456–460.

Salomon, I., & Ben-Akiva, M. (1983). The Use of the Life-Style Concept in Travel Demand Models. Environment and Planning A: Economy and Space, 15(5), 623–638.

Salon, D. (2016). Estimating pedestrian and cyclist activity at the neighborhood scale. Journal of Transport Geography, 55, 11–21.

SANDELS, S. (1977). Children in Traffic. 交通のなかのこども. https://ci.nii.ac.jp/naid/10007783837/

Sander, A. (1996). Gares et quartiers de gares I & II (Architecture Intérieure Créé, N° 262). 4.

Santoso, D. S., Yajima, M., Sakamoto, K., & Kubota, H. (2012). Opportunities and strategies for increasing bus ridership in rural Japan: A case study of Hidaka City. Transport Policy, 24, 320–329.

Sarker, M. J., Morimoto, A., Koike, H., & Ono, A. (2002). Impact of Transportation Infrastructure Development on Modal Choice. Journal of Urban Planning and Development, 128(2), 59–76.

Sarper, S. (2018). Enabling cycling access to rail stations: Prioritizing and bridging unsafe connections.

Sattlegger, L., & Rau, H. (2016). Carlessness in a car-centric world: A reconstructive approach to qualitative mobility biographies research. Journal of Transport Geography, 53, 22–31.

Sauvant, A. (2002). Volume et partage modal du transport de marchandises en france de 1845 à nos jours. 8.

Schafer, A. (1998). The global demand for motorized mobility. Transportation Research Part A: Policy and Practice, 32(6), 455–477.

Schäfer, A. (Ed.). (2009). Transportation in a climate-constrained world. MIT Press.

Schauder, S. A., & Foley, M. C. (2015). The relationship between active transportation and health. Journal of Transport & Health, 2(3), 343–349.

Scheiner, J. (2006). Housing mobility and travel behaviour: A process-oriented approach to spatial mobility: Evidence from a new research field in Germany. Journal of Transport Geography, 14(4), 287–298.

Scheltema, N. (2012). ReCYCLECity. Delft University of technology.

Schepers, P., Twisk, D., Fishman, E., Fyhri, A., & Jensen, A. (2017). The Dutch road to a high level of cycling safety. Safety Science, 92, 264–273.

Schiller, P. L., Bruun, E. C., & Kenworthy, J. R. (2010). An introduction to sustainable transportation: Policy, planning and implementation. Earthscan.

Schoner, J. E., Cao, J., & Levinson, D. M. (2015). Catalysts and magnets: Built environment and bicycle commuting. Journal of Transport Geography, 47, 100–108.

Schweizer, C., Racioppi, F., & Nemer, L. (2014). Élaboration de plans nationaux d'action pour les transports, la santé et l'environnement. Manuel pas à pas destiné aux décideurs et planificateurs. https://www.euro.who.int/fr/publications/abstracts/developing-national-action-plans-on-transport,-health-and-environment.-a-step-by-step-manual-for-policy-makers-and-planners

Scoccimarro, R. (2007). Le rôle structurant des avancées sur la mer dans la baie de Tôkyô: Production et reproduction de l'espace urbain [These de doctorat, Lyon 2]. https://www.theses.fr/2007LYO20098

Seidensticker, E. (2010). Tokyo from Edo to Showa 1867-1989. Tuttle Publishing. https://www.tuttlepublishing.com/books-by-country/tokyo-from-edo-to-showa-1867-1989

Sels, P., Vansteenwegen, P., Dewilde, T., Cattrysse, D., Waquet, B., & Joubert, A. (2014). The train platforming problem: The infrastructure management company perspective. Transportation Research Part B: Methodological, 61, 55–72.

Seo, T., Kusakabe, T., & Asakura, Y. (2015). Estimation of flow and density using probe vehicles with spacing measurement equipment. Transportation Research Part C: Emerging Technologies, 53, 134–150.

Servaes, J. (Ed.). (2017). Sustainable Development Goals in the Asian Context (Vol. 2). Springer Singapore.

Servigne, P. (2017). Imaginer l'avenir des villes. Barricade, 40.

Shaheen, S. A. (2016). Mobility and the sharing economy. Transport Policy, 51, 141–142.

Shaheen, S. A., Guzman, S., & Zhang, H. (2010). Bikesharing in Europe, the Americas, and Asia: Past, Present, and Future. Transportation Research Record: Journal of the Transportation Research Board, 2143(1), 159–167.

Sheffi, Y. (1984). Urban transportation networks: Equilibrium analysis with mathematical programming methods. Prentice-Hall.

Shelat, S., Huisman, R., & van Oort, N. (2018). Analysing the trip and user characteristics of the combined bicycle and transit mode. Research in Transportation Economics, 69, 68–76.

Shelton, B. (2012). Learning from the Japanese City: West Meets East in Urban Design. Taylor and Francis. http://qut.eblib.com.au/patron/FullRecord.aspx?p=241967

Sherwin, H. (2010). Bike-rail integration as one sustainable transport solution to reduce car dependence. https://uwe-repository.worktribe.com/output/979572/bike-rail-integration-as-one-sustainable-transport-solution-to-reduce-car-dependence

Sherwin, H., & Parkhurst, G. (2010). The promotion of bicycle access to the rail network as a way of making better use of the existing network and reducing car dependence. https://uwe-repository.worktribe.com/output/974762

Sherwin, H., Parkhurst, G., Robbins, D., & Walker, I. (2011). Practices and motivations of travellers making rail–cycle trips. Proceedings of the Institution of Civil Engineers - Transport, 164(3), 189–197.

Shibayama, T. (2015). Cycling in Japan, an unknown country with (slightly different) cycling culture.

Shibayama, T. (2017a). Organizational structures of urban public transport—A diagrammatic comparison with UML. Transportation Research Procedia, 25, 3674–3693.

Shibayama, T. (2017b). Japan's transport planning at national level, natural disasters, and their interplays. European Transport Research Review, 9(3), 44.

Shibayama, T., & Ieda, H. (2011). MOLTS: Multinational Operators for Local Transport Services. Asian Transport Studies, 1(3), 234–249.

Short, J., & Caulfield, B. (2014). The safety challenge of increased cycling. Transport Policy, 33, 154–165.

Shoup, D. C. (1997). The High Cost of Free Parking. Journal of Planning Education and Research, 17(1), 3–20.

Silva, V. (2011). Bike Infrastructures and Design Qualities: Enhancing Cycling. Danish Journal of Geoinformatics and Land Management, 46(0105–4570).

Siman-Tov, M., Radomislensky, I., Peleg, K., Bahouth, H., Becker, A., Jeroukhimov, I., Karawani, I., Kessel, B., Klein, Y., Lin, G., Merin, O., Bala, M., Mnouskin, Y., Rivkind, A., Shaked, G., Sivak, G., Soffer, D., Stein, M., & Weiss, M. (2018). A look at electric bike casualties: Do they differ from the mechanical bicycle? Journal of Transport & Health, 11, 176–182.

Skov-Petersen, H., Jacobsen, J. B., Vedel, S. E., Thomas Alexander, S. N., & Rask, S. (2017). Effects of upgrading to cycle highways—An analysis of demand induction, use patterns and satisfaction before and after. Journal of Transport Geography, 64, 203–210.

Small, K. A. (2007). The Economics of Urban Transportation (2nd ed.). Routledge.

Smith, C. (2016). Car-free cities: Healthier citizens (continued). Environment International, 476, 2.

Smith, T. W., Axon, C. J., & Darton, R. C. (2013). The impact on human health of car-related air pollution in the UK, 1995–2005. Atmospheric Environment, 77, 260–266.

Snizek, B., Sick Nielsen, T. A., & Skov-Petersen, H. (2013). Mapping bicyclists' experiences in Copenhagen. Journal of Transport Geography, 30, 227–233.

Soest, D. V. (2016). Differences in Accessibility between Rail Journeys through Main Stations and Side-Stations.

Song, Y., Preston, J., & Ogilvie, D. (2017). New walking and cycling infrastructure and modal shift in the UK: A quasi-experimental panel study. Transportation Research Part A: Policy and Practice, 95, 320–333.

Song, Y.-J., & Shoji, K. (2016). Effects of diversification strategies on investment in railway business: The case of private railway companies in Japan. Research in Transportation Economics, 59, 388–396.

Song, Z., He, Y., & Zhang, L. (2017). Integrated planning of park-and-ride facilities and transit service. Transportation Research Part C: Emerging Technologies, 74, 182–195.

Sorensen, A. (2002). The Making of Urban Japan: Cities and Planning from Edo to the Twenty-First Century (Vol. 53). Psychology Press.

Sørensen, A. Ø. (2014). An Investigation Into Braess' Paradox and Selfish Routing in Traffic Flow. Norwegian University of Science and Technology.

Soulas, C., & Papon, F. (2003). Les conditions d'une mobilite alternative a l'automobile individuelle. REALITES INDUSTRIELLES. https://trid.trb.org/view/966453

Soulas, Claude, Abours, S., Heran, F., Papon, F., & Richer, C. (2012). Développer l'intermodalité vélo et transport collectif: Un éclairage donné par le projet Predit Port-Vert. Ville Rail et Transport, 536 S, 6p.

Speck, J. (2013). Walkable City: How Downtown Can Save America, One Step at a Time (Reprint edition). North Point Press.

Spickermann, A., Grienitz, V., & von der Gracht, H. A. (2014). Heading towards a multimodal city of the future? Technological Forecasting and Social Change, 89, 201–221.

Spinetta, J.-C. (2018). L'avenir du transport ferroviaire (p. 127). Ministère de la transition écologique.

Staricco, L., & Vitale Brovarone, E. (2018). Promoting TOD through regional planning. A comparative analysis of two European approaches. Journal of Transport Geography, 66, 45–52.

Steele, M. W. (2010). The Speedy Feet of the Nation: Bicycles and Everyday Mobility in Modern Japan. The Journal of Transport History, 31(2), 182–209.

Steele, M. W. (2012). The Making of a Bicycle Nation. Transfers, 2(2), 70–94.

Steg, L. (2003). CAN PUBLIC TRANSPORT COMPETE WITH THE PRIVATE CAR? IATSS Research, 27(2), 27–35.

Steinmetz, G. (2004). Odious Comparisons: Incommensurability, the Case Study, and "Small N's" in Sociology. Sociological Theory, 22(3), 371–400.

Stiglitz, P. J. E. (2009). Rapport de la Commission sur la mesure des performances économiques et du progrès social. 324.

Stinson, M. A., & Bhat, C. R. (2004). An Analysis of the Frequency of Bicycle Commuting Using an Internet-Based Survey. 21.

Stoffers, M. (2012a). Cycling as Heritage: Representing the History of Cycling in the Netherlands. The Journal of Transport History, 33(1), 92–114.

Stoffers, M. (2012b). Cycling as Heritage: Representing the History of Cycling in the Netherlands. The Journal of Transport History, 33(1), 92–114.

Stoffers, M. (2019). Modernizing the Bicycle: The International Human-Powered Vehicle Movement and the "Bicycle Renaissance" since the 1970s. In Invisible Bicycle (pp. 180–214). Brill.

Stoffers, M., Oosterhuis, H., Cox, P., Mom, G., Norton, P., Clarsen, G., Pirie, G., History, & RS: FASoS MUSTS. (2010). Bicycle history as transport history: The cultural turn. In Mobility in history: Themes in transport. T2M Yearbook 2011. (pp. 265–274). Éditions Alphil-Presses universitaires suisses. https://cris.maastrichtuniversity.nl/en/publications/3908e163-b974-4262-b281-2eef49df4e29

Strømann-Andersen, J., & Sattrup, P. A. (2011). The urban canyon and building energy use: Urban density versus daylight and passive solar gains. Energy and Buildings, 43(8), 2011–2020.

Sulejic, D., Jiang, R., Sabar, N. R., & Chung, E. (2017). Optimization of lane-changing distribution for a motorway weaving segment. Transportation Research Procedia, 21, 227–239.

Sun, G., & Zacharias, J. (2017). Can bicycle relieve overcrowded metro? Managing short-distance travel in Beijing. Sustainable Cities and Society, 35, 323–330.

Sussman, J. M. (2005). Perspectives on intelligent transportation systems (ITS). Springer Science+Business Media.

Suzuki, K., Kanda, Y., Doi, K., & Tsuchizaki, N. (2012). Proposal and Application of a New Method for Bicycle Network Planning. Procedia - Social and Behavioural Sciences, 43, 558–570.

Suzuki, K., Tsuchizaki, N., Kanda, Y., & Doi, K. (2014). Evaluating Demand Change Following the Development of a Bicycle-Friendly Environment. 3(1), 14.

Suzuki, M., & Nakamura, H. (2017). Bike sharing deployment and strategies in Japan (p. 27).

Suzuki, T. (1995). A Vision of Future Railway Stations. 8.

Tagaris, K. (2012). Squeezed by debt crisis, Greeks ditch cars for bikes. Reuters. https://jp.reuters.com/article/uk-greece-bicycles-idUKBRE8770LT20120808

Talebian, A., & Zou, B. (2016). A multi-stage approach to air-rail competition: Focus on rail agency objective, train technology and station access. Journal of Rail Transport Planning & Management, 6(1), 48–66.

Tanaka, S., Hasegawa, N., Iizuka, D., & Nakamura, F. (2017). Evaluation of vehicle control algorithm to avoid conflicts in weaving sections under fully-controlled condition in urban expressway. Transportation Research Procedia, 21, 199–207.

Tanaka, W. (2014). TOD project pratices in Japan.

Tanishita, M., & van Wee, B. (2017). Impact of vehicle speeds and changes in mean speeds on per vehicle-kilometer traffic accident rates in Japan. IATSS Research, 41(3), 107–112.

Tatsuzo, U. (1981). The development of the Japanese bicycle industry in Japan after World War II. Bernan Press.

Taylor, D., & Mahmassani, H. (1996). Analysis of Stated Preferences for Intermodal Bicycle-Transit Interfaces. Transportation Research Record: Journal of the Transportation Research Board, 1556(1), 86–95.

Tekniska, K., Ex, T., Van, F., & Walle, D. (2004). The Velomobile as a Vehicle for more Sustainable Transportation.

Terrien, C., Maniak, R., Chen, B., & Shaheen, S. (2016). Good practices for advancing urban mobility innovation: A case study of one-way carsharing. Research in Transportation Business & Management, 20, 20–32.

Tetsuo, Y. (2018). Bicycle transport and railway station area development.

The Urban Task Force. (2003). Towards an Urban Renaissance (1st ed.). Routledge.

Thomas, Rachel, Rémy, N., & Léothaud, I. (2011). L'accessibilité des réseaux de transport en commun en Europe (p. 150).

Thomas, Ren, Pojani, D., Lenferink, S., Bertolini, L., Stead, D., & van der Krabben, E. (2018). Is transit-oriented development (TOD) an internationally transferable policy concept? Regional Studies, 52(9), 1201–1213.

Thompson, C., & Ratkoff, F. (2000). Un troisième sexe? Les bourgeoises et la bicyclette dans la France fin de siècle. Le Mouvement Social, 192, 9–39.

Thomsen, M. K. M., & Elle, M. (2016). An examination of existing car-free projects and a future development of a car-free environment in Middelalderbyen. Aalborg University.

Tight, M., Timms, P., Banister, D., Bowmaker, J., Copas, J., Day, A., Drinkwater, D., Givoni, M., Gühnemann, A., Lawler, M., Macmillen, J., Miles, A., Moore, N., Newton, R., Ngoduy, D., Ormerod, M., O'Sullivan, M., & Watling, D. (2011). Visions for a walking and cycling focussed urban transport system. Journal of Transport Geography, 19(6), 1580–1589.

Tironi, M. (2013). La ville comme expérimentation: Le cas du Vélib' à Paris. ParisTech.

Tiry, C. (2002). Learning from Japanese stations. 建築雑誌, 1492, 40–41.

Tison, O. (1997). Une évaluation globale de la congestion à partir de l'enquête transports. Une Évaluation Globale de La Congestion à Partir de l'enquête Transports, 57, 53–66.

Tjong Tjin Tai, S.-Y., Veraart, F., & Davids, M. (2015). How the Netherlands became a bicycle nation: Users, firms and intermediaries, 1860–1940. Business History, 57(2), 257–289.

Toi, S., Kajita, Y., & Nishikawa, S. (2012). Effective removal method of illegal parking bicycles based on the quantitative change after removal. Journal of Japan Society of Civil Engineers, Ser. D3 (Infrastructure Planning and Management), 68, 15–29.

Tolley, R. (2003). Sustainable Transport: Planning for Walking and Cycling in Urban Environments. Woodhead Publishing Ltd.

Tomita, Y., & Nakayama, A. (2017). Demand and cost structure analyses on Japanese successful bicycle sharing system called "Ekirin-kun" to install cycle ports at railway stations. Transportation Research Procedia, 25, 3412–3420.

Toussaint, J.-F. (2008). Retrouver sa liberté de mouvement. PNAPS: Plan National de Prévention Par l'activité Physique et Sportive.

Traffic safety policies: An international comparison of policy changes. (2012). International Symposium. https://www.iatss.or.jp/en/event/international_symposium2012.html

Tran, T. D. (2016). L'usage du vélo en libre-service: Impact de l'environnement socio-économique des stations sur la génération de la demande : application sur la Métropole de Lyon [These de doctorat, Lyon]. https://www.theses.fr/2016LYSE2179

Transport policy in perspective 2015 in Japan. (2015). Japan research center for transport policy.

Tranter, P. (2012). Effective Speed: Cycling Because It's "Faster". 19.

Tranter, P., & Australian Greenhouse Office. (2004). Effective speeds: Car costs are slowing us down : a report. Australian Greenhouse Office. http://www.greenhouse.gov.au/tdm/publications/effectivespeeds.html

Tribby, C. P., & Zandbergen, P. A. (2012). High-resolution spatio-temporal modeling of public transit accessibility. Applied Geography, 34, 345–355.

Troin, J.-F. (2008). Le réseau européen des Lignes à Grande Vitesse: Espoir ou impasse ? (The European network of high-speed rail lines : hope or deadlock ?). Bulletin de l'Association de géographes français, 85(4), 475–486.

Tronchet, D. (2014). Petit traité de vélosophie. Plon.

Tsenkova, S., & Mahalek, D. (2014). The impact of planning policies on bicycle-transit integration in Calgary. Urban, Planning and Transport Research, 2(1), 126–146.

Tucker, V. A. (1975). The energetic cost of moving about: Walking and running are extremely inefficient forms of locomotion. Much greater efficiency is achieved by birds, fish—and bicyclists. American Scientist, 63(4), 413–419.

Unwin, N. C. (1995). Promoting the public health benefits of cycling. Public Health, 109(1), 41–46.

Vale, D. S. (2015). Transit-oriented development, integration of land use and transport, and pedestrian accessibility: Combining node-place model with pedestrian shed ratio to evaluate and classify station areas in Lisbon. Journal of Transport Geography, 45, 70–80.

Van Acker, V., Van Wee, B., & Witlox, F. (2010). When Transport Geography Meets Social Psychology: Toward a Conceptual Model of Travel Behaviour. Transport Reviews, 30(2), 219–240.

van Amelsvoort, L. G. P. M., Spigt, M. G., Swaen, G. M. H., & Kant, Ij. (2006). Leisure time physical activity and sickness absenteeism; a prospective study. Occupational Medicine, 56(3), 210–212.

van de Velde, D. M. (2013). Learning from the Japanese railways: Experience in the Netherlands. Policy and Society, 32(2), 143–161.

Van der Spek, S. C., & Scheltema, N. (2015). The importance of bicycle parking management. Research in Transportation Business & Management, 15, 39–49.

van Duppen, J., & Spierings, B. (2013). Retracing trajectories: The embodied experience of cycling, urban sensescapes and the commute between 'neighbourhood' and 'city' in Utrecht, NL. Journal of Transport Geography, 30, 234–243.

van Goeverden, K., Nielsen, T. S., Harder, H., & van Nes, R. (2015). Interventions in Bicycle Infrastructure, Lessons from Dutch and Danish Cases. Transportation Research Procedia, 10, 403–412.

Van Heijningen, H. M. C. (2016). Exploring the Design of Urban Bike Sharing Systems intended for Commuters in the Netherlands. https://repository.tudelft.nl/islandora/object/uuid%3Ab9d45c90-4ed3-478c-8c98-abcde3d687ab

van Wijnen, J. H., Verhoeff, A. P., Jans, H. W., & van Bruggen, M. (1995). The exposure of cyclists, car drivers and pedestrians to traffic-related air pollutants. International Archives of Occupational and Environmental Health, 67(3), 187–193.

Van Zeebroeck, B. (2017). BitiBi report 2017.

Vande Walle, S., & Steenberghen, T. (2006). Space and time related determinants of public transport use in trip chains. Transportation Research Part A: Policy and Practice, 40(2), 151–162.

Veeneman, W. (2018). Developments in public transport governance in the Netherlands; the maturing of tendering. Research in Transportation Economics, 69, 227–234.

Veillette, M.-P., Grisé, E., & El-Geneidy, A. (2018). Park 'n' Roll: Identifying and Prioritizing Locations for New Bicycle Parking in Québec City, Canada. Transportation Research Record: Journal of the Transportation Research Board, 2672(36), 73–82.

Viaut, J.-M., & Kaminagai, Y. (2001). La signalétique multimodale de la RATP. Actes INRETS (Arcueil), 109–116. http://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=1020490

Vickerman, R. (2017). Beyond cost-benefit analysis: The search for a comprehensive evaluation of transport investment. Research in Transportation Economics, 63, 5–12.

Vinti, C. (2016). Petit apport terminologique à l'histoire de la moto. Publifarum, 26.

Virginia Tech, & Buehler, R. (2018). Can Public Transportation Compete with Automated and Connected Cars? Journal of Public Transportation, 21(1), 7–18.

Virkler, M. R. (1998). Prediction and Measurement of Travel Time Along Pedestrian Routes. Transportation Research Record, 1636(1), 37–42.

Vivanco, L. A. (2013). Reconsidering the bicycle: An anthropological perspective on a new (old) thing. Routledge.

Vogel, M., Hamon, R., Lozenguez, G., Merchez, L., Abry, P., Barnier, J., Borgnat, P., Flandrin, P., Mallon, I., & Robardet, C. (2014). From bicycle sharing system movements to users: A typology of Vélo'v cyclists in Lyon based on large-scale behavioural dataset. Journal of Transport Geography, 41, 280–291.

von der Tann, L., Sterling, R., Zhou, Y., & Metje, N. (2020). Systems approaches to urban underground space planning and management – A review. Underground Space, 5(2), 144–166.

Vuk, G., Burge, P., Rohr, C., & Bates, J. (2004). Review of international experience in VOT study design. European Transport Conference 2004. https://orbit.dtu.dk/en/publications/review-of-international-experience-in-vot-study-design-2

Wang, M., & Zhou, X. (2017). Bike-sharing systems and congestion: Evidence from US cities. Journal of Transport Geography, 65, 147–154.

Wang, Y., Chau, C. K., Ng, W. Y., & Leung, T. M. (2016). A review on the effects of physical built environment attributes on enhancing walking and cycling activity levels within residential neighborhoods. Cities, 50, 1–15.

Wardlaw, M. J. (2014). History, risk, infrastructure: Perspectives on bicycling in the Netherlands and the UK. Journal of Transport & Health, 1(4), 243–250.

Wardman, M. (1998). The value of travel time. A review of british evidence. Journal of Transport Economics and Policy, 32(3). https://trid.trb.org/view/504353

Wardman, M., & Hine, J. (2000). Costs of Interchange: A Review of the Literature. http://www.its.leeds.ac.uk/

Wardman, M, Page, M., Tight, M., & Siu, Y. L. (2000). Cycling & Urban Commuting: Results of Behavioural Mode and Route Choice Models. 31.

Wardman, Mark. (2004). Public transport values of time. Transport Policy, 11(4), 363–377.

Wardman, Mark, Batley, R., Laird, J., Mackie, P., Fowkes, T., Lyons, G., Bates, J., & Eliasson, J. (2013). Valuation of travel time savings for business travellers. https://uwe-repository.worktribe.com/output/926633/valuation-of-travel-time-savings-for-business-travellers

Washington, S., Karlaftis, M. G., Mannering, F., & Anastasopoulos, P. (2020). Statistical and Econometric Methods for Transportation Data Analysis. CRC Press.

Watcher, S., Theys, J., & Orfeuil, J. P. (2005). La mobilite urbaine en debat. Cinq scenarios pour le futur ? DEBATS, N46. https://trid.trb.org/view/946861

Wegener, M. (2013). The future of mobility in cities: Challenges for urban modelling. Transport Policy, 29, 275–282.

Wegman, F., Zhang, F., & Dijkstra, A. (2012). How to make more cycling good for road safety? Accident Analysis & Prevention, 44(1), 19–29.

Welleman, T. (1995). The autumn of the Bicycle Master Plan: After the plans, the products. Presentation at the Velo-City Conference, 95.

Wenglenski, S. (2006). Regards sur la mobilité au travail des classes populaires. Une exploration du cas parisien. Undefined. /paper/Regards-sur-la-mobilit%C3%A9-au-travail-des-classes-Une-Wenglenski/1fe078fb628970f38a4536311ddc8e8f4ecdccaa

Willson, R. W. (2015). Parking management for smart growth. Island Press.

Woods, R., & Masthoff, J. (2017). A comparison of car driving, public transport and cycling experiences in three European cities. Transportation Research Part A: Policy and Practice, 103, 211–222.

Wramborg, P. (2000). VISION ZERO et la nouvelle approche en matière d'urbanisme, de réseau de voies et de conception des rues.

Wramborg, P. (2005). A New Approach to a Safe and Sustainable Road Structure and Street Design for Urban Areas. Proceedings of the Road Safety on Four Continents Conference, 13, 12p.

Wright, L. (2005). Car-free development, a sourcebook for policy-makers in developing cities (p. 168).

Xing, Y., Volker, J., & Handy, S. (2018). Why do people like bicycling? Modeling affect toward bicycling. Transportation Research Part F: Traffic Psychology and Behaviour, 56, 22–32.

Xu, J., Zhang, Z., & Rong, J. (2012). The Forecasting Model of Bicycle Parking Demand on Campus Teaching and Office District. Procedia - Social and Behavioural Sciences, 43, 550–557.

Yai, T. (2018). Road traffic and environment, simulation stuby urban environment.

Yamaguchi, K., & Yamasaki, K. (2009). The high-speed inter-city transport system in Japan, past, present and the future (p. 36). International Transport Forum.

Yan, X., Levine, J., & Marans, R. (2019). The effectiveness of parking policies to reduce parking demand pressure and car use. Transport Policy, 73, 41–50.

Yang, R., Yan, H., Xiong, W., & Liu, T. (2013). The Study of Pedestrian Accessibility to Rail Transit Stations based on KLP Model. Procedia - Social and Behavioural Sciences, 96, 714–722.

Yedla, S. (2015). Urban Transportation and the Environment. Springer India.

Yonnet, P. (1984). La société automobile. Le Debat, n° 31(4), 128–148.

Yoshida, S. (2009). Bicycle Traffic Accidents in Japan. 6.

Zahavi, Y. (1973). The tt-relationship: A unified approach to transportation planning. Traffic Engineering & Control, 15 N(n/5). https://trid.trb.org/view/120096

Zandvliet, R., Bertolini, L., & Dijst, M. (2008). Towards Planning for a Mobile Society: Mobile and Residential Populations and the Performance of Places. European Planning Studies, 16(10), 1459–1472.

Zayed, M. A. (2016). Towards an index of city readiness for cycling. International Journal of Transportation Science and Technology, 5(3), 210–225.

Zemp, S., Stauffacher, M., Lang, D. J., & Scholz, R. W. (2011). Classifying railway stations for strategic transport and land use planning: Context matters! Journal of Transport Geography, 19(4), 670–679.

Zhao, P., & Li, S. (2017). Bicycle-metro integration in a growing city: The determinants of cycling as a transfer mode in metro station areas in Beijing. Transportation Research Part A: Policy and Practice, 99, 46–60.

Zhou, H., & Gao, H. (2020). The impact of urban morphology on urban transportation mode: A case study of Tokyo. Case Studies on Transport Policy, 8(1), 197–205.

Ziv, J. C., & Napoleon, C. (1981). Le transport urbain: Un enjeu pour les villes. https://trid.trb.org/view/1043570

Zuo, T., Wei, H., & Rohne, A. (2018). Determining transit service coverage by non-motorized accessibility to transit: Case study of applying GPS data in Cincinnati metropolitan area. Journal of Transport Geography, 67, 1–11.

Reports

Cycling Embassy of Denmark

Cycling embassy of Denmark. (2009). Danish cycling know-how.
Cycling embassy of Denmark. (2017a). Copenhagen city of cyclists, facts and figures.
Cycling embassy of Denmark. (2017b). Cycling report for the capital region.
Danmark, & Transportministeriet. (2014). Denmark - on your bike: The national bicycle strategy. Transportministeriet.
Weinreich, M., & Kabell, M. (2017). Let us promote cycling in cities around the world together.

Cycling Embassy of Japan

Cycling embassy of Japan. (2015a). *Cycling handbook*.

Cycling embassy of Japan. (2015b). *Infographics*.

Cycling embassy of Japan. (2016a). *Spring report*.

Cycling embassy of Japan. (2016b). *Winter report*.

Cycling embassy of Japan. (2017a). *Fall-winter report*.

Cycling embassy of Japan. (2017b). *Spring report*.

Dutch cycling embassy

Dutch cycling embassy. (2014). *Brochure*.
Van Woerkom, G. (n.d.). *The Dutch and their bikes* (p. 2017).

International Transport Forum

International Transport Forum. (2013). *Cycling, Health and Safety*. OECD.

International Transport Forum. (2015). *Le vélo, santé et sécurité*. OECD.

International Transport Forum. (2016). *Road safety annual report—Japan*.

International Transport Forum. (2017a). *Linking people and places, new ways of understanding spatial access in cities*.

International Transport Forum. (2017b). *Strategic infrastructure planning, international best practice*.

International Transport Forum. (2018a). *Integrating urban public transport systems and cycling*.

International Transport Forum. (2018b). Light protection of cycle lanes, best practices. *Best Practices*, 23.

International Transport Forum. (2018c). *Safer city streets global benchmarking for urban road safety*.

International Transport Forum. (2019). *Benchmarking accessibility in cities, measuring the impact of proximity and transport performance*.

MLIT

MLIT. (2004). *Traffic safety measures in Japan*.

MLIT. (2005). *都市交通における自転車利用のあり方に関する研究*.

MLIT. (2010). *Japan transport policy in perspective*.

MLIT. (2012a). *New approaches to reduce road traffic accidents in Japan*.

MLIT. (2012b). *三大都市圏の混雑率*. MLIT.

MLIT. (2012c). *自転車等駐車場の整備のあり方に関するガイドライン*.

MLIT. (2013). *Promotion of urban renovation and compact cities*.

MLIT. (2015a). - *コミュニティサイクルの普及について—資料 3*.

MLIT. (2015b). *Creating safe and secure road spaces for cyclists*. MLIT.

MLIT. (2015c). *Japan transport policy in perspective*.

MLIT. (2015d). *PPP models for sustainable urban development*.

MLIT. (2015e). *平成 27 年度全国都市交通特性調査結果（速報版)*.

MLIT. (2015f). *自転車交通*.

MLIT. (2015g). *都市における人の動きとその変化 27*.

MLIT. (2016a). *今後の進め方(案)について—資料 3*.

MLIT. (2016b). *安全で快適な自転車利用環境創出ガイドライン*.

MLIT. (2016c). *「自転車ネットワーク計画策定の早期進展」と「安全な自転車通行空間の早期確保」に向けた提言*.

MLIT. (2017a). *Challenge to new goals in road transport, preparation of the 10th traffic safety basic plan (road transport).*

MLIT. (2017b). *White paper on land, infrastructure, transport and tourism in Japan.*

MLIT. (2017c). *自転車の活用の推進に関する現状の取り組みについて*.

MLIT. (2017d). *自転車活用推進について*.

MLIT. (2018a). *Roads in Japan*.

MLIT. (2018b). *Transport and environment in Japan*.

MLIT. (2018c). *駅周辺における放置自転車等の実態調査の集計結果*.

MLIT. (2019). *自転車通勤導入に関する手引き*.

MLIT, & Nishimoto, T. (2017). *国土交通省における環境対応車の普及に向けた取組国土交通省 自動車局 環境政策課長西本俊幸*.

MLIT, & NTSEL. (2016). *Pedestrian safety research in Japan*.

MLIT, & Sone, S. (2008). *GHG reduction approaches of transport sector in Japan*. 14.