DOCTORAL DISSERTATION

博　士　論　文

A STUDY ON EQUITY ENHANCEMENT BY MAAS PROJECTS: CASE STUDIES IN MAEBASHI, SHIZUOKA AND SHOBARA

MAASプロジェクトによる公正性向上に関する研究：前橋、静岡、庄原の事例研究

Yokohama National University

Graduate School of Urban Innovation

国立大学法人　横浜国立大学大学院都市イノベーション学府

CHINBAT TUGSDELGER

チンバト　トゥゲルデルゲル

September

2023年9月

A STUDY ON EQUITY ENHANCEMENT BY MAAS PROJECTS: CASE STUDIES IN MAEBASHI, SHIZUOKA AND SHOBARA

MAASプロジェクトによる公正性向上に関する研究：前橋、静岡、庄原の事例研究

By

CHINBAT TUGSDELGER

チンバト　トゥゲルデルゲル

A dissertation submitted to the Graduate School of Urban Innovation

in partial fulfillment of the requirements for the degree of

Doctor of Engineering

Examining Committee

Professor Dr., Mihoko MATSUYUKI (Chair)

Professor Dr., Fumihiko NAKAMURA (Co-Chair)

Professor Dr., Shinji TANAKA

Professor Dr., Yasuhiro FUJIOKA

Professor Dr., Ryosuke ABE

September

2023 年 9 月

Acknowledgments

I owe my thanks to many people, but I unfortunately cannot name all of them as their names do not fit on this page. I would like to express my sincerest gratitude to the faculty and staff at Yokohama National University for their unwavering support and guidance throughout my doctoral journey. The quality of education and research opportunities provided by the university have been instrumental in shaping my academic and professional development.

I would like to extend my heartfelt thanks to my academic advisor, Dr. Mihoko MATSUYUKI and Dr. Fumihiko NAKAMURA for their insightful mentorship, supervision, advice, and invaluable guidance from the very early stage of this research as well as giving me extraordinary experiences throughout the work.

I would like to extend my heartfelt thanks to Professor Dr. Shinji TANAKA, Dr. Ryosuke ABE and Dr. Yasuhiro Fujioka for their valuable contribution, constructive ideas and suggestions throughout my research. Furthermore, I'm deeply grateful to Dr. Yusuke KANDA and Dr. Gen HAYAUCHI for their support to conduct my research. Their expertise, guidance, and encouragement were invaluable in shaping my research and allowing me to achieve my goals. Their support and willingness to share their knowledge and insights were greatly appreciated and will not be forgotten.

I am grateful to Yokohama National University, the Graduate School of Urban Innovation, Transportation and Urban Engineering for accepting me as a student and for their unwavering support provided to me throughout the last two years. I am also incredibly thankful to Mr. Masaru HARAYAMA and Ms. Minako KOIWA for their kind support and help during my time in the Laboratory of Urban and Transportation Engineering.

I would also like to extend my gratitude to my colleagues and fellow students who have become a second family to me. Their support and encouragement have been a source of comfort

during the challenging times. I am grateful for their friendship and the memories we have created together.

Last but not least, I would like to thank the Ministry of Education, Culture and Sports, Science and Technology, JAPAN for their support which enabled me to focus on my research and complete my doctoral studies with ease. The financial assistance provided by the scholarship was a great relief and allowed me to concentrate on my studies without any worries.

A special thanks ultimately to all those who helped me conduct this research, but to whom I could not mention here.

Above all, I would like to thank my parents and my brothers for their continuous support and encouragement. I could not complete my research without their presence in my life. Without their support, guidance, and encouragement, I would not have been able to achieve this milestone. I will always be grateful for their contributions to my academic and professional growth.

Abstracts

The unprecedented demographic change of Japan's aging society has led to an increase in Mobility-as-a-Service (MaaS) projects in rural areas. Japan's motivations for implementing MaaS are diverse, and its vision and objectives are very clear and target oriented. The government has focused on deploying MaaS to address the mobility issues of its declining and rapidly aging population. However, whether these projects can achieve equity goals and assure accessibility to all is under question.

People with transportation access can easily join socioeconomic activities. However, insufficient accessibility levels hinder this engagement, causing the inequitable distribution of transportation benefits. Accessibility distribution for nonwork activities has become a serious issue, especially in rural Japan's aging population. Using the National Integrated Transport Analysis System's travel survey data, this study aims to evaluate whether MaaS can enhance social equity and accessibility levels, specifically for vulnerable groups in most need of aid in rural Japan. Measuring equity through accessibility is crucial, but it is equally important to consider which accessibility approach is being used as it can greatly impact the effectiveness of achieving equity. To assess accessibility distribution for nonwork activities, person- and place-based accessibility measures provided detailed observations of individual accessibility levels across social groups. The Gini coefficient and Lorenz curve measured the fairness of transportation benefits distribution for different transportation modes.

In the transport sector, the need to assess social equity has become more evident, and efforts have been extended to study social isolation, well-being, quality of life, and opportunities and resources access. Mobility is a facilitator of well-being and goes beyond the desire for independence, social connections, "normalness," and travel for its own sake. In other words, the lack of mobility limits out-of-home activities and reduces contact with friends and family, which may cause social isolation and a decrease in quality of life, life satisfaction, and,

most importantly, well-being. Hence, there is a need to understand the travel needs of older people to establish better transportation systems, examine how MaaS can be expanded, and clarify its effects on improving the well-being of older people.

Therefore, this study aims to explore the influence of artificial intelligence (AI) on-demand buses in Shobara, Japan, on well-being in later life by considering the satisfaction level from out-of-home activities and life, freedom to go out, and social isolation. The main focal variables to assess social equity in this study are resources (i.e., car ownership and driving ability), opportunities (i.e., access to out-of-home activities), outcomes (i.e., frequency of physical activities and visits to friends and family), and well-being. Among these variables, well-being is the study's primary concern.

Older people's satisfaction with their out-of-home activities and life, social isolation, and freedom to go out were collected through travel survey data recorded by the National Integrated Transport Analysis System during the MaaS demonstration project. A structural equation model was used to find the correlation between these variables and well-being. These measures also compared different population groups, adjusting for sex, marital status, car ownership, and driving ability. We directly interviewed older people to ask them if they need help performing out-of-home activities and why they refrain from going out. Social isolation was computed by incorporating marital status; frequency of contact with friends, family, and children; and participation in social activities.

Last objective of this study is to examine institutional organization frameworks and targeted MaaS development's equity impacts. We defined equity objectives and their indicators to achieve such mobility solutions with MaaS. It seeks to explore equity impact in two different MaaS cases developed and implemented by the government and the private sector. Accessibility, affordability, and inclusivity have been chosen as equity objectives in this study, along with six different equity indicators to measure the equity evidence of two MaaS projects.

Questionnaires were prepared separately for each case, and the heads of these projects were interviewed about equity concerns.

Transportation was less accessible to the elderly than to young and middle-aged people, and bus accessibility was unequal. Nevertheless, the AI on-demand shuttle caused a remarkable decrease in the accessibility inequity of two out-of-home activities. The results showed that mobility satisfaction correlates to the number of trips that older people take or activities they attend but that those who lost their driving ability made significantly fewer trips. 25% of the people answered that they are not satisfied with their out-of-home activities and most of the respondents want to increase the daily activity of shopping and visiting friends and family. People who refrain from going out have a low level of social isolation, which is also connected to their satisfaction with life.

The study concluded that AI on-demand bus demonstration project resulted in increased out-of-home activities, leading to improved well-being in later life. Similarly, it demonstrated the importance of maintaining well-being in rural Japan by exploring new transportation options through a social equity framework and a greater understanding of older people's needs and satisfaction levels.

The findings indicate that equity is not highly or may not even be prioritized in both MaaS cases. Nevertheless, MaaS projects in Japan have distinct characteristics to achieve specific goals. Therefore, this study suggests conceptual and practical ways or implications for incorporating transportation equity goals into these newly implemented MaaS services in Japan.

Table of Contents

List of Figures

List of Tables

CHAPTER 1 Introduction

1.1. Background

The population of Japan has significantly decreased since 2008, when it was approximately 128.08 million. One out of every four Japanese citizens is over 65, the highest percentage in the world, and the median age is 48.4 years (UN, 2021). By 2050 and 2100, the population of Japan will be below 100 million, according to the National Institute of Population and Social Security Research's (IPSS) Population Projections for Japan.

Although Japan's overall population has decreased, several big cities' populations have continuously increased (Mori & Anttiroiko, 2022). Local municipalities have been trying to mitigate the population decline by initiating policies; however, it is extremely difficult to prevent the natural decrease through urban and regional policies. This decline leads to an issue of decreasing transportation demand in rural areas and, at the same time, increasing and crowding transport demand in the cities.

Additionally, the lack of accessible transportation options in rural areas has created barriers for residents, particularly the elderly and those with disabilities, in terms of accessing essential services and participating in social and economic activities. The situation has become more critical in recent years with the acceleration of aging and declining population in rural areas. At the same time, it is evident that we are living longer than ever before; as a result, maintaining mobility as we age is more crucial than it was for earlier generations.

Government and private sector initiatives to enhance rural mobility and raise accessibility in rural areas have been made in an effort to address this issue. These initiatives consist of creating alternate modes of transportation including community buses and ride-sharing services, as well as the improvement of existing transportation infrastructure and the promotion of active transportation options such as walking and cycling. Furthermore, the Japanese government has been supporting new mobility systems through implementing MaaS since 2019. In most cases,

on-demand bus or micromobility have been implemented as a first stage of MaaS integration. However, whether these new MaaS projects can bring improved equity level is still an open question.

Transportation equity exists when different demographics have equal access to transportation, regardless of location, neighborhood, age, gender, income, religion, or any other disaggregation. An inequitable society results in unequal access to education, employment, daily activities, and social interaction, thereby disabling citizens from being a part of society. Studies have shown that social equity in mobility is critical for ensuring that all individuals have access to the resources and opportunities they need to fully participate in society. Deakin, E., and Smart, M, (2003) has shown that transportation plays a significant role in shaping access to employment, education, and healthcare. Therefore, providing equitable access to social as well as economic opportunities is the primary objective of the transportation system. It is crucial to understand who benefits from transportation services and whether different population groups are equitably experiencing its benefits and costs.

In recent years, there has been increasing recognition of the need for a more comprehensive approach to ensuring social equity in transportation, one that recognizes the interconnections between transport modes, access to resources and opportunities, and social exclusion. Policymakers and practitioners are increasingly working to develop transportation policies and programs that promote social equity, including policies that promote affordable and accessible public transportation, walkable and bikeable communities, and inclusive mobility programs for underserved populations. Policymakers and government institutions began to devote considerable resources to supporting and maintaining an extensive multi-model transportation network (Susan Shaheen and Adam Cohen, 2017). The European Commission states that promoting equity within and between generations is one of the focal points when defining sustainable transport. The US Department of Transportation (USDOT) is committed to

pursuing a comprehensive approach to advancing equity for all by highlighting wealth creation, the power of community, interventions, and expanding access. In the United Kingdom, the Social Exclusion Unit was established to monitor and influence policy, and it also collated a wide body of research evidence focused on transport and social exclusion, which led to the recommendation of a new approach on accessibility planning. In addition, it has proactively worked to systematically create and reinforce social exclusion (Lucas, 2006).

1.2. Statement of the problem

Although Japan has a world-renowned train system, its rural mobility has long been in decline and inefficient in many areas as a result of an aging and declining population. Bus services have decreased by 11,000 route km from 2006 to 2011, which is 2.7% of the total bus services in Japan (Adorno et al., 2018). In particular, in local areas of Japan, many bus operators have fallen into a vicious cycle where the number of bus services has decreased because of a dwindling user count, resulting in a reduction of convenience, which reduces the number of users further (Sakai, 2020).

One of the main challenges regarding public transport in rural Japan is the financial burden of its subsidizing—a problem that will continue to worsen—leading to the low profitability of the transport system. Studies mentioned that rural public transportation systems often struggle to cover their operating costs, leading to the need for subsidies due to their lower levels of population and economic activity. Furthermore, because of the spread of COVID-19 and the government's request for travel self-restriction, travel demand has decreased significantly, with about a 90% decrease in intercity transportation and about a 60% decrease in intracity transportation (Harata, 2020).

As the number of elderly drivers is rising, car accidents caused by them are also increasing. Therefore, it is essential to improve the mobility of older people who no longer drive and maintain their autonomy, independence, and quality of life. According to studies, mobility

challenges faced by older people in rural areas lead to dependence on family members and caregivers, less access to health care and social services, and less engagement in fewer community activities. Providing an alternative means of transportation is one way to help achieve these aims (Arai et al., 2011). Thus, Japan took action on handing legal status to the shared transportation business to promote the use of community buses, shared taxis, and municipal buses (Kimura, 2016). On top of that, the country is also trying to find a way to advance MaaS to improve mobility for tourists, women, and the elderly.

1.3 Research goal and objectives

The main goal of the study is to research determine whether new mobility services such as MaaS can enhance social equity, specifically for vulnerable groups in most need of aid. In order to achieve this main goal, the following objectives have been set:

1. To investigate whether implementing and delivering MaaS associated with spatial accessibility consideration possibly help to enhance social equity.
    a. To identify how the social equity conceptualized, operationalized, and prioritized relative to accessibility and mobility.
    b. To examine how accessibility to key activities varies in different social groups.
    c. To develop social equity assessment methodology varies among social groups.
2. To analyse well-being measures from an equity perspective and explore if Maas can possibly contribute to it.
    a. To investigate older people's unmet travel needs and satisfaction with different out-of-home activities.
    b. To build well-being measures and find the correlation.
3. To examine institutional organization frameworks and targeted MaaS development's equity impacts.

a. To identify the coordination and differences in roles of central and local government
b. To develop equity indicators and objectives.
c. To recommend MaaS facilitators as well as government to prioritize equity issues and ensure equity in MaaS developments.

1.4 Scope and limitations

We chose to study Shobara MaaS because the present study focuses on a rural region in Japan that has experienced a significant decline in population, resulting in an inefficient local transport system. Additionally, the study seeks to draw insights from a successful case study with a 2–3-year history. It's worth mention that Shobara MaaS is on a trial stage hence, data on frequency usage of AI on-demand bus is limited. Therefore, this research does have some limitations of having a limited sample size. The survey was conducted in the entire Hiroshima area with 255 participants, but we eliminated citizens outside the study area in Shobara. Therefore, the number of trips was only 52, another limitation of this study.

When we calculated the travel time, we excluded the waiting time for public transportation; instead, the shortest travel time between the origin, the zone centroid for each origin zone, and the destination is calculated for each mode. The travel times for public transport were extremely optimistic, which was the limitation of our study. There are concerns that individuals may lie or not be reliable about their level of well-being however, this study has alleviated these conditions. Additionally, well-being modeling did not include the frequency of Shobara AI on-demand buses since the main questionnaire survey of citizens did not cover it.

Categorization of MaaS cases in Japan can be made in several way, but our focus is on the category of the institutional organization. Therefore, we narrowed possible case studies into two representative MaaS cases. Thus, we only analyzed these two leading MaaS projects that can be considered successful and were operated since MaaS began implementation in Japan.

1.5 Structure of the dissertation

This dissertation is organized into 9 chapters and appendices (Fig.1.1). The first chapter outlines the research problems and the rationale behind the research. In addition, the objectives of the study are highlighted herein. The remaining chapters are presented as follows:

Chapter 2 sets out the literature review upon which this study is built upon. A preview of the studies related to equity and equity in transportation in different countries including Europe, United States, and Japan. The chapter also summarizes equity assessment methods that has been used in previous studies.

Chapter 3 describes the definition and characteristics of MaaS developments in different countries. How these MaaS developments addressed equity issues in their projects also been summarized.

Chapter 4 provides the research methodology employed and case studies. Fundamental features and the background of MaaS deployments in Shobara, Maebashi, and Shizuoka are described.

Chapter 5 addresses measuring equity using spatial accessibility as an indicator. Two different accessibility measure studied in this chapter to calculate non-work accessibility level in Shobara.

Chapter 6 is devoted to well-being of older people and how its measurements correlated. This chapter also explained older people's unmet travel needs and inequal well-being of different groups of people in Shobara.

Chapter 7 discusses two different MaaS deployments and their equity considerations using equity indicators. The chapter also addresses institutional organization frameworks and targeted MaaS development's equity impacts.

Chapter 8 uses the outcomes from the previous chapters to summarize lessons we learned from the different MaaS case studies. This is preceded by integrating various equity outcomes from different perspectives.

Finally, chapter 9 presents the key findings of this study as well as their policy implications, followed by recommendations for future research.

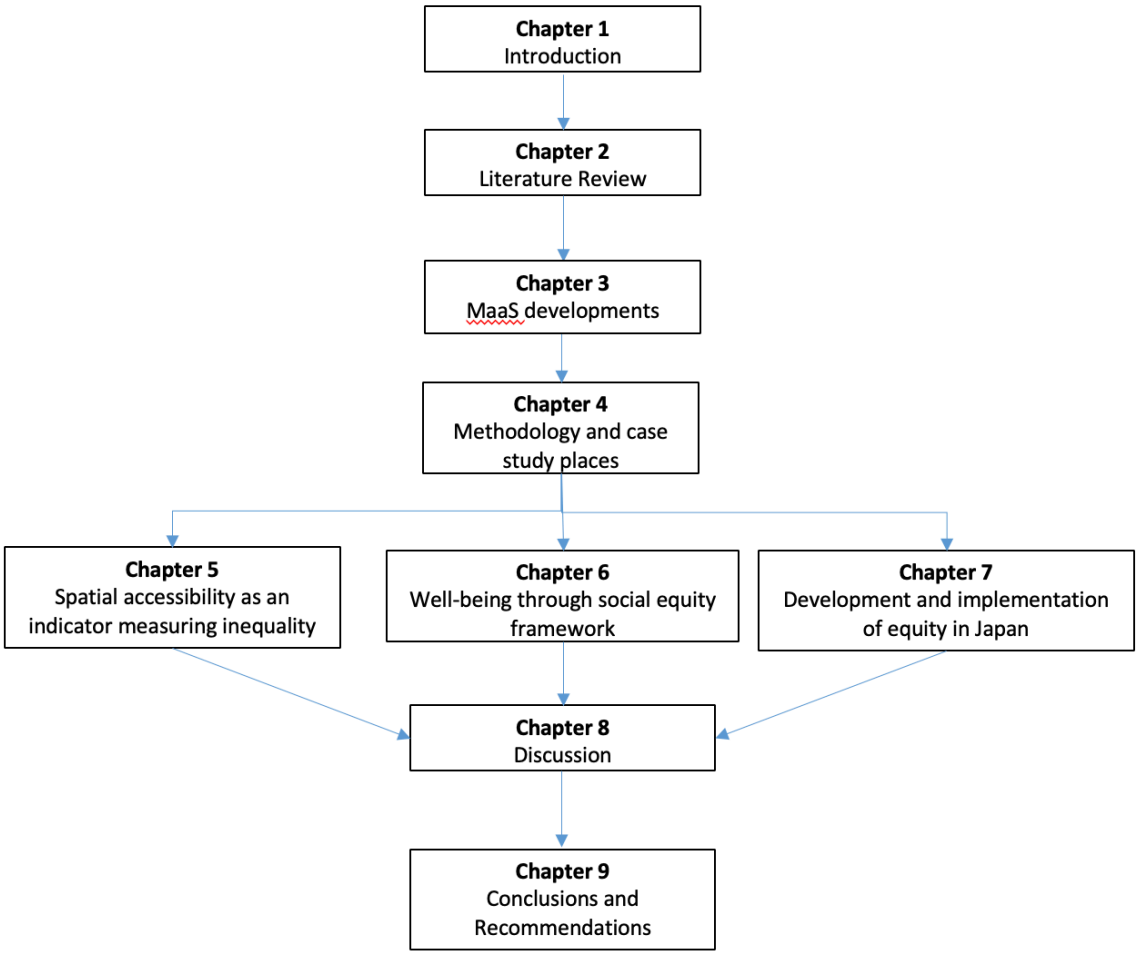


Figure 1.1. Research framework

CHAPTER 2

Literature Review

2.1 Definition of Equity

The term “equity” refers to fairness and justice and is distinguished from equality: Whereas equality means providing the same to all, equity involves acknowledging that not everyone starts from the same place and must acknowledge and make adjustments to imbalances (NACE). The term “social equity” (also called “social justice” or “fairness”) refers to the distribution of effects (benefits and costs) and whether this is seen as fair and appropriate (Litman, 2016). The issue of equity (distributive justice) relates to how social and economic inequalities among society's members are shaped by the institutions and laws that govern it. It asks who benefits from and is burdened by policies, as well as to what extent, and focuses on the evaluative standards used to assess their results (Behbahani et al., 2019).

Social equity theories define people’s rights and obligations, based on various political-economic ideologies. Economic (distributive), political, organizational/administrative, cultural, educational, legal, and criminal/judicial equity are a few of these that might be discussed (Behbahani et al., 2019). There are several equity theories in human science including socialism, liberalism, and religions based which are Christianity and Islamic perspective which provides history and fundamental principles of social equity theories.

The background of social equity theory is studied and mentioned in few studies to clarify how should the distribution of impacts be evaluated and prioritized. Those ethical theories in terms of equity and justice theories, including utilitarianism, libertarianism, intuitionism, Rawls’ egalitarianism, and sufficientarianism. Pereira et al. (2016) used the terms “justice” and “equity” interchangeably, van Wee et al. (2011) stated that the latter could be equated with “fairness” and “justice,”. This study focused on sufficientarian and egalitarian theories because Pereira and Karner (2021) stated that they are concerned with both absolute levels of well-

being, transportation-related poverty, social exclusion, and relative levels of transportation-related inequalities. Sen (1992) defined egalitarians as those that believe all people should be treated equally. Specifically, egalitarian theories focus on social group differences, questioning why certain groups or areas have higher or lower accessibility levels and not absolute levels of well-being. Sufficientarianism similarly assumes that everybody should be well-off and possess a minimum threshold accessibility level to key destinations.

2.2 Equity in mobility

Since the turn of the century, equity consideration has become more central to transportation planning and appraisal. Manaugh et al. (2015) revealed that many jurisdictions, organizations, and experts are starting to apply sustainable transportation planning principles to balance economic, social, and environmental objectives. Moreover, some studies mentioned that more comprehensive impact analysis is required, including considering social equity effects (Arsenio et al., 2016). The equity analysis is multifaceted because there are several types of equity, many potential effects to consider, and different ways to measure these effects and categorize people. Pereira and Karner (2021) stated that transportation equity frames distributive justice concerns about how social, economic, and government institutions shape transportation benefits and costs distribution across all sectors of society.

Discussion about equity in transport planning often includes two different types of equity: horizontal and vertical equity. Vertical equity means the distribution of an action's effects among people, groups, or geographical areas with various needs and abilities. According to this standard, policies are deemed equitable if they help geographically, economically, or socially marginalized groups or regions and if the gap between privileged and disadvantaged individuals is narrowed (Behbahani et al., 2019). Meanwhile, horizontal equity refers to the uniform distribution of benefits and costs among individuals within a group. Based on egalitarian theories, it refrains from favouring one individual or group over another. The spatial

distribution of transportation impacts is the focus of the majority of studies on horizontal equity (El-Geneidy et al., 2016). Figure 2.1 shows the difference between two types of equity and their principle. Overall, equity in transport planning includes some combination of horizontal and vertical equity principles, such as ensuring that most groups receive some benefits, and disadvantaged groups receive the most benefits.

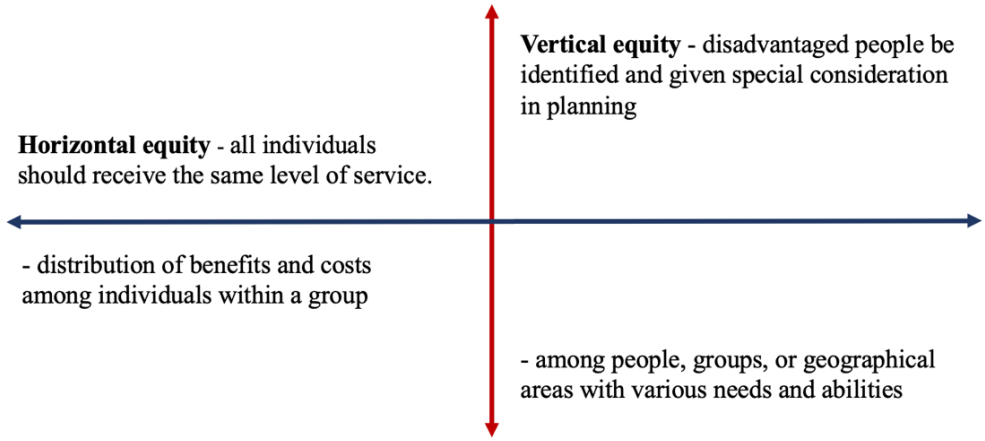


Figure 2.1. Two types of equity

Equity, nonetheless, is not so much about the unequal allocation of resources such as transport services, investments, infrastructure across space. Rather, it focuses on how policy choices affect societal levels of environmental externalities and whether groups are more or less exposed to them, as well as how they affect the lives of different groups in terms of their ability to access life-enhancing opportunities such as employment, healthcare and education (Pereira et al., 2017).

2.3 Equity issues in new transport

Numerous countries' transit agencies have begun testing the addition of new mobility systems to their services. Therefore, new mobility technologies playing a significant role from electric vehicles and shared mobility services to connected and autonomous vehicles, ride-hailing, on-demand transit, micro transit, these innovations are reshaping the way we move around. It is inevitable that new transport systems becoming major integrated components of

public transit systems, and the moment has come to consider whether and how new mobility transport will help agencies solve their problems and achieve their goals, such as providing equitable transit services (Palm et al., 2021). On the contrary, failing to take equity into account when adopting new transport could exacerbate existing disparities by adding new hurdles to participation in developing transpiration systems (Susan Shaheen & Adam Cohen, 2017).

There are some studies that examined equity or equity related implications of new mobility solutions and systems. For example, (Palm et al., 2021) studied equity-relevant issues, considerations, and findings in academic and government assessments of new mobility transport technologies (NMT) pilots through studies on discrimination and technology access barriers to NMT use and studies arguing for the potential for NMTs to improve equity. (Goralzik et al., 2022) examined an accessibility assessment of shared mobility services: (a) ride pooling, (b) microtransit, (c) motorbike taxis, (d) robotaxis, (f) e-scooter sharing, and (g) bike sharing from the perspective of people with disabilities. Social and special access equity also evaluated in regulatory frameworks for moped-style scooter sharing services (Bach et al., 2023). (Abdelwahab et al., 2021) examined the equity implications of ride hailing through a multi-modal accessibility framework.

2.4 Equity issues in different countries

The definition of equity varies, and there are several types of equity, with many potential effects to consider and various ways to measure. Therefore, how equity is defined and measured can significantly affect analysis results (T. A. Litman, 2021). Moreover, defining what needs to be examined in equity depends on the country or city, cultural characteristics, and archetype conditions. As such, developing equity indicators that are more grounded and tailored to local conditions is fundamental.

In Europe

The European Commission states that promoting equity within and between generations is one of the focal points when defining sustainable transport. In the United Kingdom, the Social Exclusion Unit was established to monitor and influence policy, and it also collated a wide body of research evidence focused on transport and social exclusion, which led to the recommendation of a new approach on accessibility planning. Moreover, inequity in transit services and inaccessibility to the rapid transit systems among different ethnic population groups in European urban areas are key concern (Bartzokas-Tsiompras & Photis, 2019). In European contexts, populations at risk of "social exclusion" from a lack of access to adequate transportation are of primary concern (Karner et al., 2020). There, specific population groups are not necessarily identified a priori, but rather individuals and locations at risk of low participation in the activities necessary to lead a meaningful life are identified and addressed (Lucas, 2012).

Environmental affect: Europe's reliance on cars has a severe influence on the environment, contributing to air pollution and greenhouse gas emissions. Many scholars suggest that the conflict between equity and the environment is evident in climate change policies (Arsenio et al., 2016). Moreover, climate change mitigation and adaptation strategies may significantly affect accessibility levels, especially for vulnerable population groups, such as low-income households, single parent households, and persons with travel-related impairments (Arsenio et al., 2016).

Accessibility: The accessibility of transport for all is a political priority of the European Commission and European Parliament placed transport as the essential service to which everyone has the right to access in 2017. However, it's one of the critical issues for many people living in rural areas and small towns in Europe especially for older adults, people with disabilities, and low-income households.

Safety: European road safety observatory pointed that road traffic crashes also have implications for social equity and have a disproportionate impact on disadvantaged citizensm, and the risk is often unevenly distributed across different groups in society. The loss of the major family wage earner in road traffic crashes can push people into poverty as well limiting the ability of victims to cope with the consequences.

Gender: In the EU, women are more likely to rely on public transportation and active modes of transportation such as walking and cycling, compared to men. European Institute for Gender Equity stated that women also on average, take a shorter time to get to work than men. Generally, men are more likely to travel directly to and from work, whereas women make more multi-purpose trips, to fit in other activities such as school drop-offs or grocery shopping. Moreover, women also encounter higher levels of harassment, negative gender stereotypes and risk of violence which can restrict their mobility and access to opportunities.

In United States

In the United States, a lack of access to transportation services in low-income and rural areas has been a persistent challenge by travel times and distances, frequency of service, cost, and limitations in funding to address these challenges (US, DoT). When we consider the distinction of population groups, ethnicity has been of particular importance in the United States, where concerns over race are high on the political agenda, also in the domain of transport. As in the United States, in most countries ethnic minority status tends to go hand in hand with multiple forms of disadvantage, but their differential share in transport-related benefits of burdens is often overlooked within equity assessment, largely due to the paucity of data (Martens et al., 2019).

There are several studies within the context of the United States and its historically racialized pattern of infrastructure investment. The researchers often use neighborhoods with disproportionate concentrations of low-income and racial minority populations as proxies for

disadvantaged populations region-wide, labeling them as “communities of concern” (Williams & Golub, 2017). National travel survey in the United States showed that people with disabilities use app-based ride-hailing services less often than other users, which points to existing barriers, like inaccessible apps and vehicles (Cochran & Chatman, 2021). The US Department of Transportation (USDOT) is committed to pursuing a comprehensive approach to advancing equity for all by highlighting wealth creation, the power of community, interventions, and expanding access. Therefore, the main definition of equity by USDOT, “Equity in transportation seeks fairness in mobility and accessibility to meet the needs of all community members. A central goal of transportation is to facilitate social and economic opportunities by providing equitable levels of access to affordable and reliable transportation options based on the needs of the populations being served, particularly populations that are traditionally underserved.”

Some potential equity issues in the United States:

- Access to transportation: There are disparities in access to public transportation, especially for underrepresented groups such as low-income households and people of color. According to a study by (Thomas et al., 2022), "people of color and low-income individuals are affected more by the inequitable outcomes in public transportation, and more likely to rely on transit as their primary mode of transportation".
- Affordability of transportation: Transportation expenses can be a significant burden for low-income households, particularly in locations with inadequate or nonexistent public transit. Twenty-eight percent of public transportation users have incomes of $15,000 or less, and 55 percent have incomes between $15,000 and $50,000. Only 17 percent have incomes above $50,000. Just 7 percent of white households do not own a car, compared with 24 percent of African-American households, 17 percent of Latino households, and

13 percent of Asian-American households (Sánchez, Thomas W. & Ma, Jacinta S., 2003).

- Health impacts: USDOT approaches that negative health effects related to the transportation system can be severely hit on vulnerable groups of the community, such as low-income residents, minorities, children, persons with disabilities, and older adults. Highways generate noise and air pollution, create visual intrusions, and affect community cohesion and people of color are disproportionately impacted by the ramifications of transportation development (Thomas et al., 2022).
- Access to jobs: Lack of transportation can be to barrier to accessing employment opportunities, particularly for low-income in who may not have access to a car or reliable public transportation. Black residents located in urban areas experience poor employment outcomes because of the combination of job suburbanization and housing discrimination (Thomas et al., 2022).

2.5 Equity issues in Japan

Japan's case is notably different from previously studied cases. It is crucial to mention that transportation equity is not clearly defined and studied in Japan. Even the terminology for "equity" in Japanese is unclear in the transportation context. Japan has a special history of local transportation being a bond and bridge between people and society. "Kizuna," which means emotional ties and bonds in Japanese, was selected as "the word of the year" in 2011, and reopening public transportation was regarded as a symbol of connections and bonds (Utsunomiya, 2016). Japan started applying a new term, "social implementation," derived from the Japan Science and Technology Agency (JST), which refers to the application and development of research results to solve social problems. Therefore, the government is prioritizing the social implementation of new demonstration projects and social acceptance by the community to meet society's needs. The business model has been confirmed as a

combination of transportation and welfare or well-being; however, as Smart Mobility Challenge (2021) points out, cooperation and unified knowledge sharing among related parties, including private industries and jurisdiction, are necessary to solve social issues.

Although Japan is considered a highly homogeneous country, 97.8% of the population of Japan are Japanese, with the remainder being foreign nationals residing in Japan, according to census statistics in 2018. Moreover, race/ethnicity and migration-based, sex-based, and income-based race/ethnicity factors in inequities are commonly found in Western studies. The researchers often use neighborhoods with disproportionate concentrations of low-income and racial minority populations as proxies for disadvantaged populations region-wide, labeling them as "communities of concern" (Williams & Golub, 2017). While race and ethnicity may not be as salient in the Japanese context, other forms of social inequity, such as gender and age-based disparities, continue to be a significant concern in transportation planning due to its rapid ageing. For instance, accessing transportation services can be particularly difficult for women and the elderly due to a lack of public transit options or limited mobility as a result of physical or cognitive limitations.

Some government reports have mentioned the importance of equity and ensure equity when planning any type of transport projects. Although, the concept of equity is not yet widely recognized in the country's transport sector, in our research, we tried to highlight various equity-related strategies that have been implemented within Japan's context. For example, the Japanese government has implemented policies to promote the use of public transportation, which can have positive effects on equity by increasing access to affordable transportation options (Basic Act on Transportation Policy, 2013). Japan's national government offers free or discounted public transportation passes for individuals with disabilities which is called "Senior Pass" program (MLIT, 2020). This program is available to individuals aged 65 and over who meet certain income requirements and provides access to free or discounted transportation on

buses, trains, and other modes of public transportation (Ministry of Health, Labour and Welfare, 2021). Furthermore, taxi vouchers are also offered to individuals with disabilities and older adults, and it can be used to pay for taxi rides, providing an alternative to public transportation for those who may have difficulty using buses or trains. Local municipalities offer different types of taxi vouchers, with varying eligibility requirements and subsidy amounts (MLIT, 2020).

Additionally, initiatives have been put in place to improve the accessibility of transportation for individuals with disabilities, such as the installation of guide blocks and step-free train stations. The practice of barrier-free design in Japan has a rich history, with the initial action of establishment and revision of guidelines having started in 1980. In 2006, a new “barrier-free” law was enacted, and extensive maintenance was created for people with disabilities, including traffic curbs, step-free train or bus stations, guide blocks, accessible toilets and chairs for wheelchair users on high-speed trains (shinkansen), and parking for people with disabilities (MLIT, 2020). In addition, Japan has established guidelines and standards for barrier-free design in transportation, such as the "Public Transport for People with Disabilities Act" and the "Guidelines for Making Pedestrian Facilities Safe and Comfortable for the Elderly and the Physically Disabled" (Japan Accessible Transport Association, n.d.).

Given these complexities, there is a growing recognition among transportation researchers and policymakers of the need to adopt a more nuanced and intersectional approach to studying transport equity in Japan, one that takes into account a range of social factors and their interactions.

2.6 Assessing transport equity.

2.6.1 Accessibility in transport inequity

Lucas et al. (2016) mentioned that numerous authors emphasized the significance of accessibility measures in evaluating the social equity and distribution inclusion impacts of transportation offerings. Accessibility has evolved into a primary concept in transportation (Ryan and Pereira, 2021), although its definitions are several and broad. One of the preliminary and most common meanings of accessibility was Hansen's (1959) simple definition of it as the "potential" to reach opportunities. Most recently, it was described by Handy (2020) as the potential for interaction opportunities.

Accessibility measures have four categorizations according to Geurs and van Wee (2004): (i) infrastructure-based, (ii) location- or place-based, (iii) person-based, and (iv) utility-based accessibility measures (Figure 1). Utility-based accessibility measures have been developed to assess the value people derive from having access to spatially distributed opportunities (Geurs and van Wee, 2004). This method can directly be integrated into an economic appraisal of transport investments, the most known being cost-benefit-analysis (CBA) (Guers, 2020). The infrastructure-based approach to measuring accessibility is used as input for the standard practice approach to measuring the accessibility benefits of transport strategies (Guers, 2020). The measures that only consider a person's ability to travel, or potential mobility, can be dismissed as inappropriate measures from an equity perspective. According to Lucas et al. (2016), accessibility can be calculated using either a place-based perspective (i.e., from one geographical location to another) or person-based measures (i.e., also considering personal characteristics, resources and capabilities, time budgets, etc.).

Kim (2018) argues that person-based accessibility is a preferable approach for two reasons: (i) unlike place-based accessibility, it incorporates temporal variations in

transportation systems and activities that affect accessibility; and (ii) it measures accessibility through an individual's unique travel behavior. Person-based measures allow for a more sensitive assessment of individual variations in accessibility, including gender, age, and ethnic differences (Neutens et al., 2010; Geurs and van Wee, 2004). A person-based accessibility measure is made through thorough observations of one's activity schedule and space-time constraints (Neutens et al., 2010). Therefore, person-based accessibility measures are potentially useful for social evaluations of transportation and land-use changes, as individual characteristics and limitations are considered (Geurs and van Wee, 2004). Additionally, Neutens et al. (2010) found person-based measures to be more conservative than place-based measures in assessing the equity level of service delivery.

Moreover, place-based measures look into the distance from desired activity locations from primary locations in one's daily life (Neutens et al., 2010). It also does not require detailed data, yet the results are easy to interpret and map. Meanwhile, person-based accessibility metrics take into account how transport and location characteristics interact with personal characteristics such as age, gender, and physical capacity to influence a person's accessibility levels (Ryan and Pereira, 2021). The major disadvantages of gravity-based accessibility measures are the need to develop an impedance factor and the appropriate weights for the destination. Combining the modes is also difficult for the gravity model (El-Geneidy et al., 2006). The gravity-based measure is not easily interpreted and communicated, as it combines land-use and transport elements and weighs opportunities (Geurs and van Wee, 2004). Meanwhile, the cumulative opportunities measure is easy to interpret. However, place-based accessibility measures fail to address accessibility on a detailed, individual level, as a person's accessibility is generally assumed to coincide with the accessibility level for the zone being resided in (Fransen and Farber, 2019). Hence, we also used person-based measures to calculate individual accessibility levels. It is also mentioned that place-based and person-based measures

are used to supplement each other's shortfalls (Geurs and van Wee, 2004). These factors make place- based and person-based measures more appropriate to address equity perspectives than other accessibility measures.

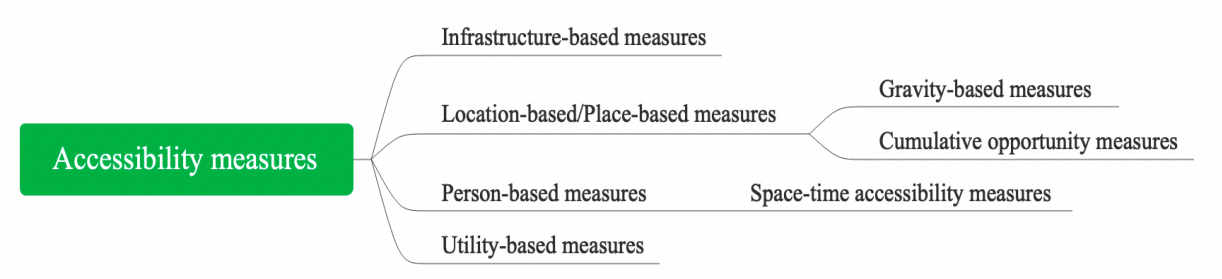


Figure 2.2 Classification of Accessibility

It is however important to define what should be measured to evaluate the equity that can reflect different groups in society and their concerns. In regards of what should be measured, accessibility often considered to assess the distribution of benefits provided by transport systems.

2.6.2 Well-being measures

A key concern within the transport sector is that inequity has extended beyond the traditional measures of travel, and now covers a wide range of effects relating to social exclusion, freedom, well-being and being able to access reasonable opportunities and resources (M. Cao et al., 2019). (Martens et al., 2019) stated key variables to assess transport equity and well-being are one of the main components and others focal are *resources* (i.e., car ownership and driving ability), *opportunities* (i.e., access to out-of-home activities), and *outcomes* (i.e., frequency of physical activities and visits to friends and family).

The objective and subjective positions represent radically different answers to questions about the nature of well-being. Therefore, it's crucial to state whether well-being is taken to be a subjective or an objective phenomenon (Nordbakke & Schwanen, 2014). Subjective well-being (SWB) stance holds an individual's own assessment of how they feel about their life in general. SWB encompasses three different aspects like positive affect such as joy and pride,

negative affect such as pain and worry, and cognitive component of satisfaction with life as a whole (Diener et al., 1985; Stiglitz et al., 2009).

(Reardon et al., 2019) used a subjective well-being lens to transportation equity by applying the day reconstruction method (DRM) to understanding the levels of subjective well-being experienced by commuters using different transport modes and show how these levels of subjective well-being can be analyzed in relation to different demographics in order to understand the equity implications. The inequity of subjective well-being within groups and across society can be an important indicator, and evidence also suggests that individuals' subjective well-being can vary considerably in response to certain life events, such as disability (OECD, 2013). Furthermore, (Adorno et al., 2018) conducted semi-structured interviews with 60 older people to examine the transport-related quality of life and well-being from social justice and equity perspective. They found that older people tend to see public transportation as vital to maintaining independence. It is also worth mentioning that most of these semi-structured interviews examined ethnicity and race-related equity.

A study by (Eppenberger & Richter, 2021) explored the relationship between well-being and transport equity among different socio-economic groups. The study used regression models, the relationship between land-use and transportation accessibility and socio-economic well-being indicators is tested on district-level in four European cities: Paris, Berlin, London and Vienna. Moreover, (Sharifi et al., 2021) stated an interesting point that inequitable green space distribution is shown to have adverse effects on SWB equity within cities, by decreasing health and well-being of members of disadvantaged communities. There are similar studies on urban systems and how infrastructure can improve human well-being and equity.

In contrast, in the objective perspective, well-being is established from the evaluation of the 'objective' circumstances in which people live, given (inherently normative) criteria based

on values, goals or objectives (Phillips 2006). In the objective perspective, well-being is defined as a person's potential in knowledge, health, friendship, and other life domains that are derived from things that are valuable in themselves not from a person's attitudes or mental state instead, it's determined by how things are in our lives (Ferdman, 2021).

Most of the previous studies evaluated subjective well-being which gives a focus on life satisfaction and some studies used quality of life interchangeably with the well-being or as a measure of well-being (Ettema et al., 2010; Mizokami et al., 2014; Reardon et al., 2019; J. K. Stanley et al., 2011). Moreover, one study examined the link between physical activity and quality of life in older adults and used quality of life as satisfaction with life (McAuley et al., 2006).

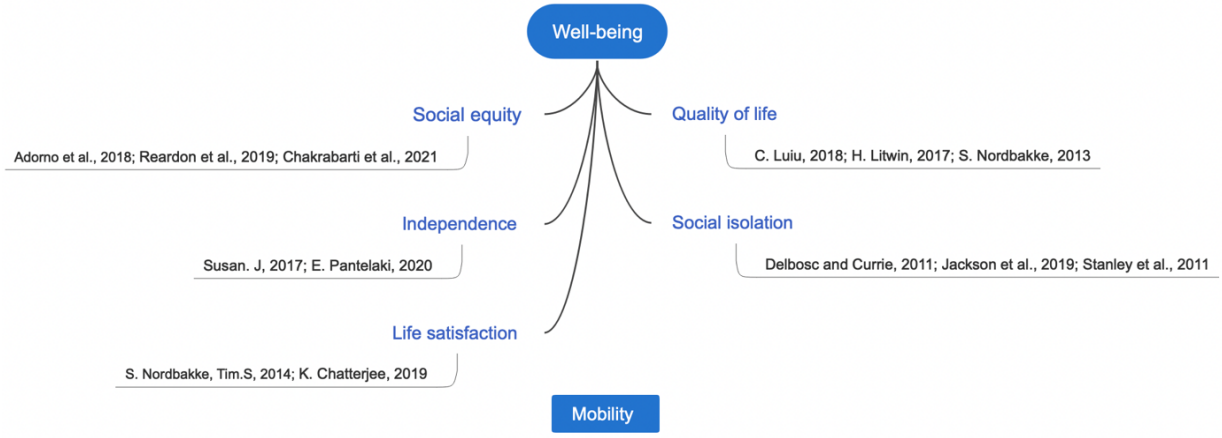


Figure 2.3 Well-being measures

Lastly, there are several measures utilized to assess well-being in the context of mobility (Figure 1). The lack of mobility limits out-of-home activities and may cause social isolation and a decrease in quality of life, life satisfaction, and most importantly, well-being.

2.6.3 Social inclusion

Social inclusion is another critical topic when we discuss equity issues in transportation. Some studies used the term social isolation, social exclusion, and social inclusion however, all has a similar concept and idea of getting excluded and isolated from social activities. In 1997, the policy interface between transport, accessibility and social exclusion theme emerged in

response to New Labour's social welfare agenda. Then, particular approach to accessibility planning that was devised by the Social Exclusion Unit (SEU), developed by Department of Transport (DfT) and passed on to local transport authorities (LTAs) to deliver (Karen Lucas, 2012). Academics, consultants, national and local policy-makers and practitioners in the UK have collaborated and pooled their knowledge to pioneer a program of research to make evident the links between transport and social exclusion however, accessibility planning for social inclusion is still in its infancy in the UK (Lucas, 2006).

Inadequate public transportation systems in low-density urban environments may also reinforce social exclusion of non-car-driving older adults (Adorno et al., 2018). With increasing fuel costs and growing social inequities, particularly single senior citizens will have to re-think car ownership. Therefore, public transport will have an increasingly important role to ensure independent living and social inclusion of large parts of society (Fiedler & Consult, 2007). Studies found that social exclusion and highly related to mobility and (J. Stanley et al., 2011) stated that significant evidence to suggest that mobility is positively correlated with the likelihood of social inclusion among adults: higher trip-making implies less risk of social exclusion.

Furthermore, as demographics shift across the world and the global population ages, the number of transportation-disadvantaged older adults who face challenges such as social exclusion and/or barriers to accessing services and supports that maintain or enhance quality of life will only increase (WHO 2007). Women, the unemployed, the elderly, people with health problems and those on low incomes are more likely to experience transport related social exclusion (UK Cabinet Office, 2004). (Manaugh et al., 2015) suggest that the application of social equity indicators should specify the impacts and improve the inclusion of disadvantaged groups.

2.6.4 Affordability and economic equity

Some studies look at affordability, which refers to transportation cost, ensuring everybody can afford basic mobility. Van Dort et al. (2019) concluded that more research is necessary to identify how new mobility options can be made more accessible for low-income communities. It is important to recognize that issues related to cost and affordability can play an important role in shaping an individual's perception of accessibility (Jones & Lucas, 2012), particularly in low-income contexts. (Y. Wang et al., 2022) found that the three latent variables of accessibility, affordability, and social impacts can be seen as representing the main characteristics of public transport equity. People's ability to use public transportation and hence their accessibility levels are dependent on affordability (El-Geneidy et al., 2016).

A number of papers have addressed this issue of affordability and the cost component of travel. (Di Ciommo & Shiftan, 2017) stated that there are two types of affordability measures can be distinguished:

- Affordability measures that focus solely on actual, revealed, travel, thus contrasting with the accessibility papers described above which focus on accessibility as a potential.
- Affordability measures that relate to a minimum amount of travel which persons may or may not make.

(T. Litman, 2020) defined affordability as a household's ability to access basic goods and activities at any time they want, such as shopping, work, healthcare and so on. Affordability means that public transport can be reached and afforded by lower or even middle-income groups at an acceptable level (Y. Wang et al., 2022).

Furthermore, a broad definition of accessibility refers, not only to physical access to goods and services, but also the transport system itself in terms of its availability (including routing and scheduling), affordability, reliability and safety, as well as access to timetable information, etc (Karen Lucas et al., 2015). Affordability of new mobility transport services raise questions

regarding the equitable distribution of transit capacity. Hence, it is important factor to consider when we talk about equity in transport.

2.7 Limitations of the existing equity studies

Considering the current shift from mobility- to accessibility-based transportation policies, we found it vital to examine whether emerging or existing transportation systems affect or improve accessibility levels for different social groups. Manaugh et al. (2015) and Di Ciommo and Shiftan (2017) stated that social equity goals and targets are, in many instances, not translated into clearly specified targets, and apt measures for evaluating their achievement in a meaningful, disaggregated way are often lacking. Cao et al. (2019) also mentioned that very few empirical studies sought to study various inequality measures and their function in evaluating individual social inequality in transport.

Most studies, such as Boisjoly et al. (2020), El-Geneidy et al. (2016), and Cui et al. (2019), predominantly examined accessibility to transportation for work, not nonwork activities. Pritchard (2019) only compared the accessibility levels of other transportation modes with private cars. Grengs (2015) revealed that studying travel modes to work is crucial because it is an essential journey; however, examining nonwork trips is also significant because social engagement is directly related to well-being and health. Furthermore, most papers distinguished accessibility levels and social equity by ethical and racial groups (Grengs et al., 2013; Yeganeh et al., 2018; Vecchio et al., 2020), but it may not be a necessary indicator for a highly ethnically homogenous country like Japan, where 98.5% of the population is Japanese. A more pertinent factor is age, an increasingly serious problem for the nation.

Most papers examined accessibility levels using location-based accessibility (for example, different neighborhoods or urban vs. suburban) (Di Ciommo et al., 2017). However, one's access to an activity or opportunity is not solely determined by where one lives but is also affected by one's physical ability and personal travel preferences. Therefore, this study

examined social equity issues using both person- and place-based accessibility measures. It is still an open question how the implementation of new on-demand public transport in another way, specifically MaaS for the elderly, could improve equitable access to activities.

Additionally, the connections between mobility and well-being are mainly conceptual, and little empirical evidence is available in the literature (Cao, 2013). To our knowledge, no prior work has examined well-being through the lens of transport equity. Transport policy makers have begun to associate the ability to be mobile with having a role in the facilitation of social inclusion. However, the further connection to well-being is not as well understood (Stanley et al., 2011). Therefore, there is a need to study whether different population groups especially older people are equitably experiencing transport or not besides if a new type of mobility system especially AI on-demand bus which has been studied in this paper can enhance well-being in later life.

Several studies focus on the equity impacts of MaaS, alternatives to seniors' mobility through phone apps (Shirgaokar, 2020), and societal goals of MaaS, including social inclusion, well-being, and health (Butler et al., 2021; Pangbourne et al., 2020; Sochor et al., 2018). However, little academic work has been done to identify how the classification of MaaS has equity impacts and whether different institutional frameworks suit the development of MaaS to address equity aspects. In addition, the knowledge about facilitating MaaS developments and what diffusion of MaaS might bring about in society is limited (Smith & Hensher, 2020).

CHAPTER 3

MaaS developments

3.1 Definition and developments of MaaS

MaaS can be considered one of the new concepts in the transport industry. Many researchers have explored the conceptualization of MaaS (Durand et al.,2018.; Jittrapirom et al., 2017; Sochor et al., 2018), defined different levels of integration for MaaS (e.g., Kamargianni et al., 2016; Lyons et al., 2019), assessed the potential effects of MaaS diffusion (Keller et al., 2018), and emphasized the importance of collaboration of a wide range of MaaS stakeholders (Mulley & Kronsell, 2018; Polydoropoulou et al., 2020; Smith et al., 2018).

Durand et al. (2018) described Mobility-as-a-Service (MaaS) as a new transportation concept that integrates existing and new mobility services into a single digital platform, providing customized door-to-door transport and offering personalized trip planning and payment options. MaaS is a nascent innovative transport idea (Jittrapirom et al., 2017), which explains its rapid promotion through the past few years. Kamargianni and Matyas (2017) similarly defined MaaS as a user-centric, intelligent mobility distribution model where all mobility service providers' offerings are aggregated by a sole mobility provider, the MaaS provider, and supplied to users through a single digital platform. However, Jittrapirom et al. (2017) contended that current assessment frameworks are insufficient in systematically classifying MaaS's unique characteristics.

Even though MaaS was previously described as the "new transport paradigm" (Aapaoja et al., 2017; König et al., 2016), it is not a new transport pattern in itself but rather a service model that can entail or embrace new travel behaviors, such as decreased private car ownership, servitization of transport, and increased multimodality (Smith & Hensher, 2020). In simple words, as defined by (Butler et al., 2021), MaaS is an integrated system that enables commuters

to plan, book, and pay for trips that utilize a range of mobility providers through a single online interface. MaaS has a unique feature to provide a system where new service options can be integrated with traditional transportation modes. From a user perspective, MaaS is portrayed as or aspires toward offering an appealing alternative to owning and using a private car (Lyons et al., 2019). From these various definitions, we define MaaS as a digital platform with integrated services that includes journey planning involving all modes of transport, planning, booking, e-ticketing, and payment, from the origin to the destination.

The nine core characteristics of MaaS, namely, integration of transport modes, tariff option, one platform, multiple actors, use of technologies, demand orientation (including demand-responsive services, such as taxis), registration requirement, personalization, and customization, as defined by (Jittrapirom et al., 2017), provide insights into MaaS's components. As described by (Sochor et al., 2018), MaaS is characterized by different types of integration: 0 – no integration; 1 – integration of information; 2 – integration of booking and payment; 3 – integration of the service offered, including contracts and responsibilities; and 4 – integration of societal goals. However, (Sochor et al., 2018) also stated that there is uncertainty about the nature of the MaaS-based transport system because of its lack of characterization.

A few studies mentioned that the MaaS framework should ensure the attainment of desired policy goals, such as connectivity, accessibility, equity, and environmental benefits. Moreover, MaaS could positively address accessibility and equity through a change from private to access-based transportation, as mentioned by Jittrapirom et al. (2017) and Durand et al. (2018). Some discussed that MaaS could reduce social exclusion (Pangbourne et al., 2020; Polis, 2017). (Smith et al., 2018) stated the importance of collaboration among stakeholders to ensure that MaaS can contribute to societal goals. There is an urge for new governance frameworks

that facilitate collaboration between stakeholders and are guided by societal values (Pereira and Boisjoly, 2021).

3.2 MaaS deployments in different countries

In Europe

This section provides an overview of the state of MaaS deployments in Europe, with a focus on the leading countries and cities in this field. Finland is widely regarded as the pioneer in MaaS deployment. The concept was first introduced in Helsinki in 2016, with the launch of the Whim app by MaaS Global. Through the Whim app, users can make transportation reservations and payments for combinations of public transport, taxis, car sharing and bicycle sharing. In addition to pay-as-you-go settlements, one of the distinctive characteristics of Whim is monthly subscription offering (ABeam, 2019). Whim has since expanded to other cities in Finland, such as Tampere and Turku, as well as in other countries, including Belgium, the UK, and Japan.

Another leading country in MaaS deployment is the Netherlands, where several pilot projects have been launched in recent years. In the Netherlands, central government, regional governments and market parties are experimenting with MaaS. The Ministry of Infrastructure and Water Management has developed seven MaaS pilot projects with an equal number of regions (Ministry of Infrastructure and Water Management, 2019). For example, the MaaS pilot project in the city of Groningen involves the integration of various transport services, such as public transport, shared bikes, and electric cars, into a single platform. The project aims to reduce car usage and improve the accessibility of the city, especially for those who do not own a car (Zijlstra et al., 2019).

Germany is also a key player in MaaS deployment, with several cities launching pilot projects in this field. There are several players who strive to further develop MaaS projects in the German market (Schikofsky et al., 2020). One of the most successful projects is the Moovel

app, which was launched in Stuttgart in 2013 and has since expanded to other cities in Germany, such as Berlin and Hamburg. Moovel allows users to plan, book, and pay for their journeys using various modes of transport, including public transport, car-sharing, bike-sharing, and taxis (Moovel Group GmbH, 2019).

In France, MaaS deployment is led by several startups, such as Karos and Klaxit, which offer carpooling services to commuters. In 2019, the French Mobility Orientation Law empowered Île-de-France Mobilités with a new organizational capacity for developing new forms of mobility which includes becoming a player in Mobility as a Service by offering MaaS digital medium to travellers. Île-de-France Mobilités aims to build a reference point for MaaS and development of the associated infrastructure tools (data platforms and digital media) involving a large number of private and public partners has already begun (European Metropolitan Transport Authorities, 2021). The city of Lyon has also launched a pilot project called LYVE, which aims to integrate various transport services, including public transport, bike-sharing, and carpooling, into a single platform (UITP, 2020).

In the UK, MaaS deployment is still in its early stages, with several pilot projects launched in cities such as Birmingham, Manchester, and Milton Keynes. Mobility-as-a-Service (MaaS) platform is the flagship project of the Solent Future Transport Zone (FTZ) –trialling new approaches to mobility and logistics, funded by the Department for Transport (DfT) (ITF, 2022). The vision for Mobility-as-a-Service is to create a super-app that allows customers across the Solent region to book every type of ticket, on every transport mode, for every type of trip, without the need to jump between websites or mobile apps. Current UK examples of MaaS include the app Whim in the West Midlands, and MaaS Scotland (Enoch, n.d.).

In conclusion, MaaS deployment is gaining momentum in Europe, with several countries and cities launching pilot projects in this field. While there is still much to be done to achieve a fully integrated and seamless MaaS system, the potential benefits of this concept are clear,

and it is likely that MaaS will become an increasingly important aspect of urban transport in the coming years.

In United States

Mobility as a Service (MaaS) is an emerging concept in the United States (US) aimed at integrating various transportation modes into a single platform to provide seamless access for users. Transport network companies (TNCs), such as Uber and Lyft are the largest promoters of MaaS in America, offering ride-hailing, e-scooters, and bikesharing services in their apps (Inspiratia, 2019). The US has seen significant progress in MaaS deployment in recent years, with many cities and organizations launching pilot projects. For instance, the City of Los Angeles launched the Urban Mobility in a Digital Age (UMDA) program, which aims to integrate various transportation modes into a single platform. The project focuses on integrating on-demand ride-hailing services, bike-sharing, car-sharing, and public transit into a single mobile app. The aim of UMDA is to provide users with personalized and seamless transportation options (LA Mayor's Office, 2020).

San Francisco is another leading city in MaaS deployment, with several pilot projects launched in the field. For example, the Bay Area Metropolitan Transportation Commission (MTC) launched the Clipper START program, which provides a means-based fare program for low-income residents to access multiple transit services, including BART, AC Transit, Muni, and Caltrain, using a single card (Bay Area MTC, 2020).

Other cities in the US, such as Seattle and Denver, have also launched pilot projects in MaaS deployment. Seattle has a Mobility as a Service (Maas) Partnership Program, which brings together public and private transportation providers to provide seamless and affordable transportation options for users. The program aims to reduce the number of single-occupancy vehicles on the road and improve overall transportation efficiency (Seattle Department of Transportation, 2020). Denver's "Mobility Choice Blueprint" program aims to provide an

integrated, multi-modal transportation system through a partnership between public and private organizations (Denver Regional Council of Governments, 2019).

Several organizations in the US have also taken significant steps towards MaaS deployment. Uber launched its "Uber Movement" platform, which provides traffic data to city planners and transportation organizations to aid in urban planning and policy development. Lyft also launched its "Lyft Bikes" and "Lyft Scooters" services, which allow users to rent bikes and scooters using the Lyft app. Transit, a mobile app, has integrated multiple transit modes to enable users to plan their trips and purchase tickets using a single platform.

3.3 The characteristics of MaaS projects in Japan

Since the beginning of MaaS, the Japanese government has been supportive and a driving force behind a new mobility concept. Several major steps have been taken toward implementing MaaS, and most of the projects were sponsored by the government to provide insights into policy direction. The Ministry of Economy, Trade and Industry (METI) and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) jointly started a project called “Smart Mobility Challenge” in June 2019, aiming to resolve mobility issues, especially in rural areas, through the implementation of new mobility services (Figure 3.1). Therefore, the trend toward MaaS was accelerated because of the government’s Future Investment Strategy. There are over 80 businesses in Japan, with over 80% operating in rural areas. Although most MaaS projects are not fully integrated with other existing modes, the trial of the on-demand shuttle bus is often seen as a first step of a fully integrated MaaS in those selected areas. The growing need to develop and implement MaaS to provide access to people who live in rural locations, especially vulnerable groups such as the older as well as people with disabilities, has become more apparent.

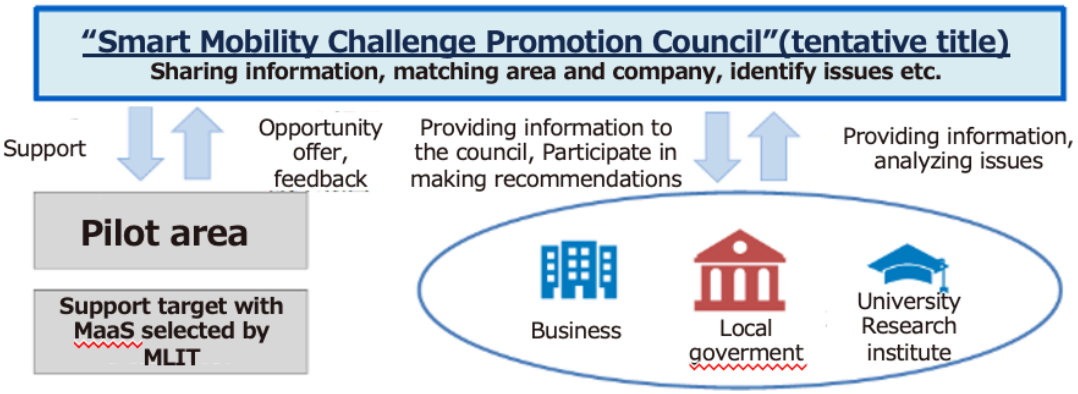


Figure 3.1. Smart Mobility Challenge Promotion (Source: MLIT, 2019)

MaaS in Japan is focused not only on providing transportation services but also on combining companies and businesses from diverse industries to provide a variety of services (ITF, 2021). The many early MaaS demonstration projects were tourism driven to improve regional economic development while securing and maintaining local transport. The recent trends in the market are more in-line with cooperation with commercial facilities to provide integrated services, such as the sale of local specialty products, restaurant services, information on travel insurance, and so forth. One of the main reasons this type of MaaS was implemented is because public transport operators offer a wide range of services in the area, including commerce, tourism, logistics, and real estate.

The study focuses on examining the social impacts of MaaS, yet its revenue stream and business model are also considered, as they are essential to the service's sustainability. Multiple MaaS market configurations exist, including business-to-consumer, business-to-business, and business-to-government-to-consumer interactions. The business-to-business structure has more immediate return since it works equally as a business market. However, it requires government action to redefine its management policies. The trend has begun with private companies initiating MaaS projects, such as Odakyu Electric Railway Co. launching its tourism oriented MaaS service in 2018. The following year, Toyota also offered tourism oriented MaaS, and service trials were carried out with various local governments. Unlike in other countries, the MaaS market was exemplified by many private companies since Japanese public

transportation is operated by private operators (ABeam, 2019). Therefore, author illustrated a MaaS model in Japan which can be divided as private MaaS operator controlled and led by the local government (Figure 3.2).

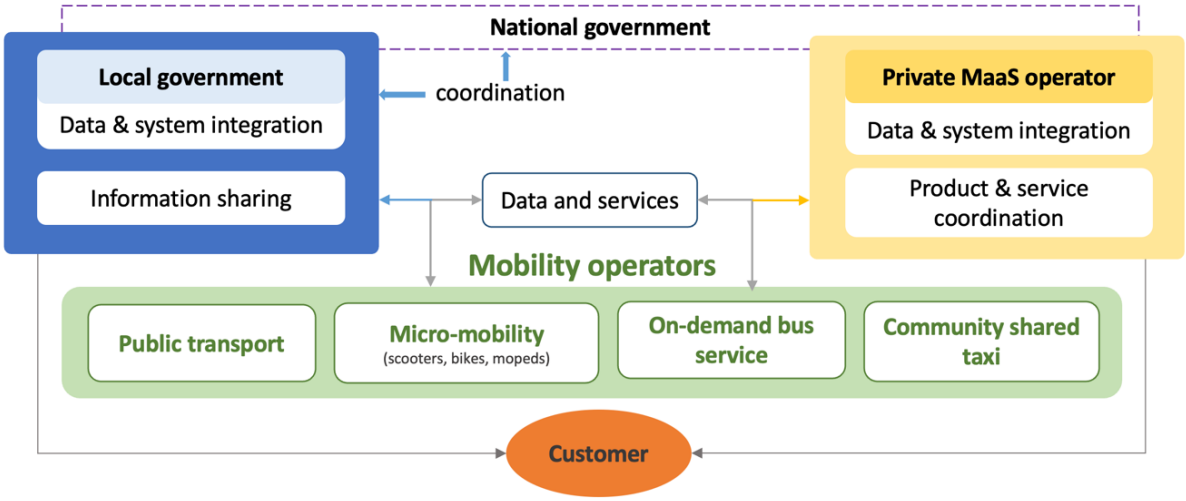


Figure 3.2 MaaS model in Japan (author's illustration)

3.4 How MaaS projects approach equity issues in different countries

In United States

American cities and states are taking some steps towards integrating their mobility systems. Efforts that drive towards MaaS are appearing in many different types of environments, including rural, to combine and streamline mobility services such as non-emergency medical transportation and paratransit in addition to the options found in larger cities. Each step expands the system, and each can be an opportunity to improve the equity of the mobility network (Shared-Use Mobility Center, 2020). Furthermore, data that can increase the transparency of transportation spending, demonstrate the utility of transportation coordination, and equitably allocate the costs of coordinated transportation (Shared-Use Mobility Center, 2020).

Travel patterns of low-income immigrants living in the lower-income areas are studies widely and concerns regarding their equitable accessibility. For example, study on transit and new mobility technologies barriers in Portland, United States, reports that people of color and

low-income residents are more likely to have had their phone plans shut- off due to lack of funds (Golub et al., 2019). Furthermore, transportation wallet in Portland is focused on affordable housing residents, the Portland Bureau of Transportation (PBOT) launched their Transportation Wallet in January of 2018. The program is available to users who live or work within one of two districts of the city, and the program's pilot focused on affordable housing residents (Portland, GOV). This program is renowned for its success in emphasizing first the neighborhoods that are left out of discussions on urban mobility. This equitable approach bucks the trend of app-based mobility providers serving only affluent, white neighborhoods in cities where transportation options are already plentiful.

Dallas Area Rapid Transit (DART) has been at the center of national conversations regarding Mobility-as-a-Service, app development, and modal integration. DART's GoPass Mobile App provides travelers the ability to plan, book and pay for the mobility solution that works best for their needs. GoPass underpins a system designed to keep DART's multimodal transit system flexible, reliable, affordable, and more available to everyone by developing new technologies and services including fare equity, cash to mobile options (American Public Transportation Association, 2022). Mentioned that equitable Dallas solution must be holistic and comprehensive and system have been examined in an inter-related and coordinated with the economy, healthcare, housing, education, transportation, and social cohesion (City of Dallas, 2017).

In Europe

Hietanen took the concept of MaaS and eventually worked with the Finnish Ministry to implement policy changes to support the concept. With a large IT industry and government finesse in promoting transit equity, Finland was a ripe place for MaaS to take off. The European systems visited see MaaS as an opportunity to capitalize on the full array of mobility options to reduce reliance on single occupant vehicles and private car ownership (APTA, 2019). It is

one of many strategies for addressing broader issues such as healthy cities, strong regional economies, improved air quality and the environment, and equity and access for all.

In Vienna, it is clear the public sector aims to take both the lead in MaaS development and also a strategic role in influencing how mobility goals are set and reached. Wiener Linien and the city infrastructure company, Wiener Stadtwerke, have jointly formed their own startup company, Upstream. Upstream is a public MaaS platform that allows for planning, payment and access to mobility services throughout the Vienna region. Vienna's public sector feels it important to have the backend of MaaS in public hands to ensure equity and data access (APTA, 2019).

There are several innovative MaaS projects that are focusing to reach people who are underserved. For example, WeWalk, the UK startup which has invented the award-winning smart cane. Paired with WeWALK smartphone app via Bluetooth, users can use hand gestures on their WeWALK device or voice assistance to access mobility services. They partnered with Moovit, MaaS application, to enhance the mobility of visually impaired people.

Moreover, study in United Kingdom mentioned that demand responsive transit services can improve the social equity of transit systems if they are adequately resourced (Palm et al., 2021). Another study noted that demand responsive service "has the most potential in areas with a low population density, a low proportion of people working from home, low car ownership, and high levels of deprivation", highlighting the equity enhancing potential of these services, at least in the United Kingdom (C. Wang et al., 2014).

In Japan

In Japan, community buses started appearing to support local transportation and secure mobility for communities through shared transportation or private vehicle transportation for on-time, fixed-route operations. Local governments are often involved in the management or funding of their operation. It is a way to cover a small-scale demand for transportation for

communities and an alternative to a private car for those who cannot drive or do not have access to a car. Therefore, mobility services using MaaS can increase their overall efficiency and significantly increase the potential to create transportation opportunities. This situation is especially true in areas without enough public transportation service frequency, which has left many people with difficulties accessing the mobility they need to support day-to-day living (Harata, 2020).

Due to population decline and social issues in rural area, most of the new implemented MaaS is in rural remote areas of Japan. (The World Economic Forum, 2020) noted main objectives of MaaS are maintain local transport and harness the market potential of transport and commerce. Mobility support for areas with limited transport and support for people with mobility difficulties are the two most found objectives of MaaS in Japan. There are many regions in Japan where people tend to not go out because their choices of destination are severely limited and mobility options. Therefore, in order to increase the uptake of mobility schemes, it is important not only to improve transport infrastructure but also to provide motivation for residents to leave their homes (World Economic Forum, 2020). For example, Choisoko MaaS offers mobility solutions with medical services and Toyoake was one of the first municipalities to address the increased medical and nursing care costs associated with ageing populations by promoting the health benefits of regular outings.

Additionally, Universal MaaS has a concept of combining universal design and MaaS and their initiative is aimed at smooth and comfortable travel, focusing on people with mobility impairments, the elderly, inbound tourists, and others (Universal MaaS). It is said that it is important to collaborate with specific businesses that match the revenue model in certain areas to advance social goals (Smart Mobility Challenge, 2021).

CHAPTER 4

Methodology and case study places

4.1 Research approach

The methodology outlines the steps followed towards the research goal and it is shown schematically in Fig.4.1. This is study used both and quantitative and qualitative research method including person- and place-based accessibility measures, Gini coefficient, explanatory analysis, Structural Equation Modelling (SEM), gray literature, and interview.

First, we calculated accessiblity level in areas where the AI on-demand bus is operating and the Shobara city center and used accessibility as an equity indicator. (Fransen & Farber, 2019) stated that place-based accessibility for each origin zone is determined by summarizing the number of locations for each destination zone accessible within a predetermined maximum cut-off travel time. The gravity-based measure is a commonly used method however, the results are not easily interpreted and communicated (Geurs & van Wee, 2004). On the other hand, the cumulative opportunities measure is easy to interpret main weakness of these measures is that all destinations within the fixed threshold are weighted equally even though distant destinations are less desirable than those nearby, and all destinations beyond the threshold distance are ignored (Grengs et al., 2013). Therefore, we also used a person-based accessibility method which could address individual accessibility. (Martens et al., 2012) stated that the cumulative opportunities measure indicates the total number of opportunities that can be reached within a given travel time or travel distance. Accessibility inequity has been compared between different modes including private cars, buses, AI on-demand buses, and walking. Moreover, the Gini coefficient is generally used to express levels of equity in income distributions, but theoretically can easily be used for any other unit such as accessibility levels of distinguished regions or groups of people as long as an interval or ratio indicator is used for several measures with analyses of other transportation modes should be applied along with the Gini Index to

compare and contrast the equity implications of different policies (Jeddi Yeganeh et al., 2018). Therefore, we used the Gini index for different regions as well as groups of people. In other words, the Gini index is used for both person- and placed-based accessibility measures.

Second, well-being was measured from equity perspective, and we used Structural equation modeling (SEM) to understand the correlation of well-being variables including satisfaction with out-of-home activities and life, freedom to go out, and social isolation. focused on addressing inequities in well-being between different social groups. In order to conduct the further examination on impact of AI on-demand, we asked users' responses on using AI on-demand buses to understand their experience and what kind of improvements is needed in the future developments. To examine how AI on-demand impacted on their frequency of travel, we also directly asked if their out-of-home activities likely to increase with implementing AI on-demand bus. Methodology that we used is mix up SEM analysis and exploratory analysis.

Lastly, fundamentally qualitative research approach has been used to understand how have institutional organization frameworks and targeted MaaS developments addressed equity impacts in Japan, and what implications can be drawn from these cases. We developed six different equity indicators to measure the equity evidence of two MaaS projects. These measures focused on examining measures that enhance transport equity using a conceptual and evidence-based framework. Specifically, we explored the contribution of MaaS in Japan towards promoting equity by conducting an extensive questionnaire survey and analyzing equity indicators and objectives. The findings provide a detailed understanding and consideration of the impact of MaaS on transport equity in Japan.

4.1.1. Research methodology framework

In this section, we will explain the quantitative methodology procedure more in detail (Fig 4.2). This study identified four key components of measuring transportation equity. The first

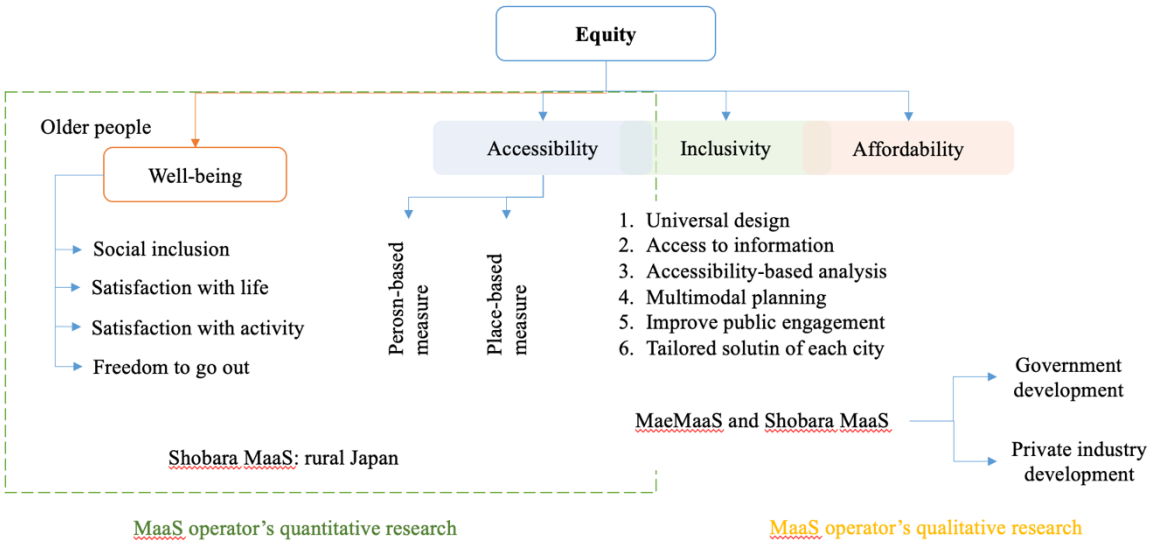


Figure 4.1 Research approach

variable, resources, referred to differences in an individual's resources or possessions, including access to different transportation means, car ownership, and walkability. The second focal variable was opportunities or the possible implications of holding a specific resource. In this study we focused on access to shopping malls and healthcare which are important out-of-home activities for older people in Japan. Third variable is outcomes, which refers to the benefits and costs obtained through the use of resources and opportunities. Fourth and last, well-being, which can be referred in line with the common understanding as persons' subjective assessment of their situation. Reardon et al, 2019 employs well-being as the focal variable and provides more detail on the way in which well-being can be understood in relation to transport.

Once we specified the benefits and costs, we followed up with next step of differentiating the population groups with age, gender, marital status etc. Then we used accessibility as a main indicator of equity and explored the association between MaaS users and well-being in later life.

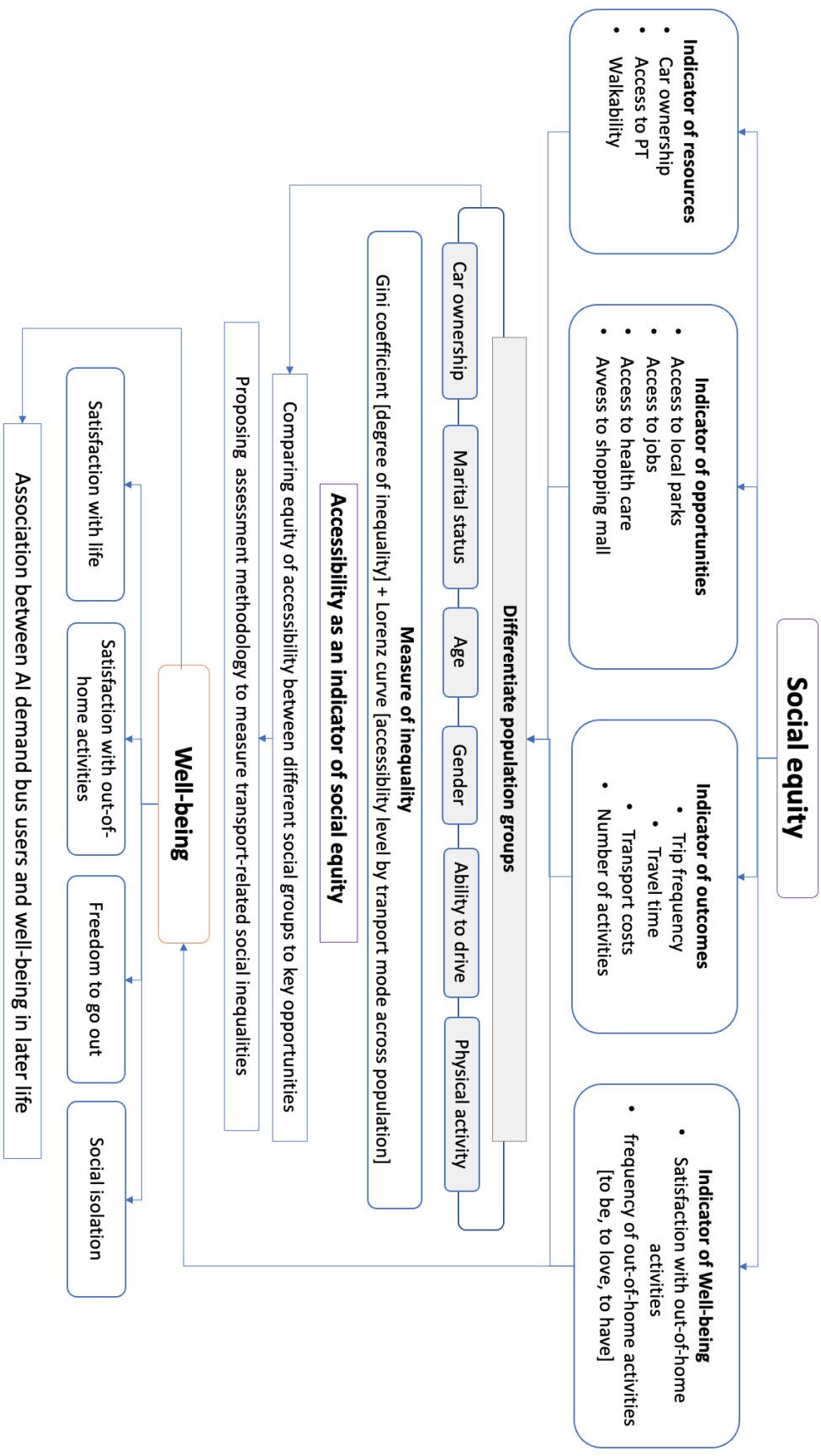


Figure 4.2. Quantitative research methodology framework

4.2 Data collection

Several travel survey datasets were collected pertaining to the Shobara MaaS system in the Hiroshima region. Although, there is a lack of information on how frequently AI on-demand buses are used because the MaaS in Shobara, Hiroshima, Japan, is still in the experimental stage. The surveys were conducted with the objective of gathering information regarding various aspects of transportation usage in the area, including frequency of travel, preferred modes of transportation, and overall satisfaction with the Shobara MaaS system. The survey respondents were selected through random sampling techniques to ensure that the results were representative of the population in the region.

The first travel survey data was collected through travel survey data from the National Integrated Transport Analysis System (NITAS, 2019) developed by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). A random sampling approach was used, but we eliminated citizens outside the study area. The main survey was conducted in the entire Hiroshima area with 255 participants, but we excluded the citizens who reside outside of our study area. Therefore, a total of 52 trip data was used in this study. The database contained self-reported trip patterns with the trip frequencies, distance, and travel times of 12 travel destinations, along with the most used transportation modes.

The second travel survey data were collected during the trial and involved trip pattern data from Shobara MaaS. The survey was conducted by the Tojo MaaS council, which consists of the Shobara city office, a commerce association, and some local community groups. It was distributed to people who used the service (n = 76) to understand the experience with AI on-demand buses. We analyzed data from a travel survey of Shobara residents conducted during the implementation of the AI on-demand bus, in which measurements were taken based on travel frequency, activities they wanted to do more of, satisfaction with life and out-of-home

activities, social isolation, and whether they needed assistance to engage in out-of-home activities freely and independently.

We used quantitative research approach to study how two different institutional organization structures of MaaS developments addressed equity impacts and implications in their respective projects. To gather data for the study, a variety of gray literature sources were used, including reports, white papers, and press releases. The data collected from these sources were analyzed to identify key similarities and differences in the institutional organization structures of the two projects, particularly in regard to their approaches to equity. To further investigate the equity implications of the two projects, semi-structured interviews were conducted with relevant head of the MaeMaaS and Shizuoka MaaS. The interviews were designed to elicit insights into the institutional organization structures of the projects and how they addressed equity considerations.

Overall, the research sought to provide a comprehensive understanding of how the MaeMaaS and Shizuoka MaaS projects approached equity, and how their respective institutional organization structures influenced their ability to address equity implications. It is also essential to add that we merely focused on MaaS services in our study therefore, other transport modes were not compared or considered in the MaeMaaS and Shizuoka MaaS cases. The findings of this research could potentially inform future MaaS development efforts and help to promote greater equity in transportation systems.

4.3 Fundamental features of the study areas

In this section, we describe the geographic features of the cities that implemented MaaS, for example, the area, population. In this study, we have studied MaaS projects in rural remote cities and mid-sized cities. The following section explains each city as follows Shobara city, Maebashi city, and Shizuoka city.

4.3.1 Shobara, Hiroshima

Socio-economic background

This study focused on the city of Shobara, located in Hiroshima, Japan, which has a total population of 37,000 people. Shobara is a city located in north-eastern Hiroshima Prefecture, Japan. Over the past seven years, since 2010, the city's population has decreased by approximately 10%, or 4,292 individuals. Shobara's aging population is also becoming increasingly apparent, with 43.9% of the total population, or 14,712 people, aged 65 and over, as reported by Shobara City in 2021 and it appears to be worsened (Fig 4.3).

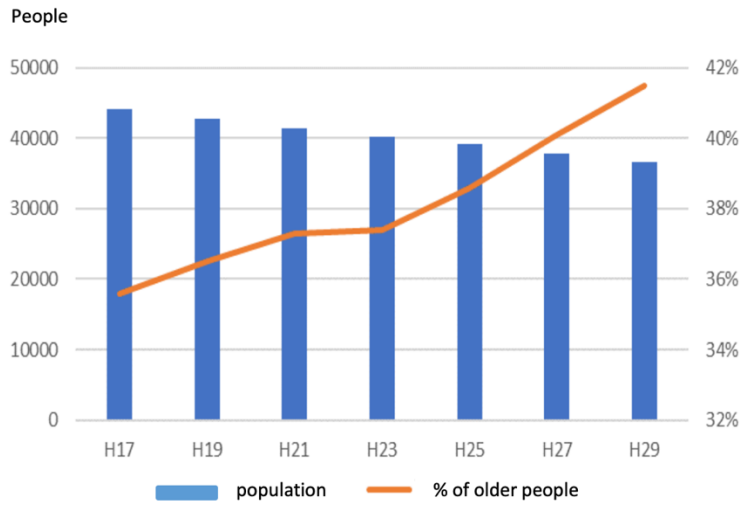


Figure 4.3 Population and rate of older people

Overview of urban and transportation developments plans

During the heavy rainfall in July 2008, there was a slope collapse on both the Hiroshima-Kure Road (Kure Line) and the JR Kure Line, leading to the closure of the road for a prolonged period. Consequently, a vast volume of traffic was redirected to the adjacent Route 31, causing severe traffic congestion. The absence of reliable means of transportation also made it challenging for people to move around in the area. The JR buses operated as a substitute for the JR Kure line, and because the buses did not support the information system, such operation created serious traffic congestion and difficulties in using public transport.

In Shobara, the number of bus stops was increased and now most of them are within 100–200 meters (around a 5-minute walk for senior people) of homes. Although it was necessary to install more bus stops on narrow roads, the city was able to circumvent the need for more bus stops on tight routes by using easy-to-manoeuvre minibuses and by having buses respond only to advance booking requests, and thus avoid any unnecessary stops (The World Economic Forum, 2020).

Current mobility issues

Existing means of transportation, such as buses, have proven to be unprofitable and challenging to maintain. The usage of public transport has declined, and the management of private operators responsible for regional transportation has deteriorated. Consequently, in the six-year period from FY2010 to FY2015, approximately 7,509 km of general bus routes were entirely abolished, and in the 15-year span from 2000 to 2015, 37 railway routes (equivalent to around 754 km) were abandoned (Akagi et al., 2021). Furthermore, the number of regions without public transport is progressively increasing year by year. In 2011, around 36,477 km, accounting for approximately 30% of Japan's inhabitable land, was recognized as an area lacking public transportation.

The shortage of transportation workers, particularly bus drivers, has become a significant challenge for many transportation companies. The lack of available drivers has led to constraints on route development and service expansion, as there are simply not enough drivers to operate new or additional routes (MLIT, 2020).

Moreover, car dependence is high due to its poor public transportation and becomes a challenging issue for older people who live many depopulated areas. Thus, social exclusion of the aging society is one of the main challenges in Shobara. In addition, public transport services in depopulated areas often do not provide information services such as timetable searches and real-time location information, which may lead to an increase in the number of

car users and a decrease in the number of visitors, as people assume that public transport is not available.

Overview of Shobara MaaS

Shobara, Hiroshima, where a local MaaS–artificial intelligence (AI) on-demand shuttle has been implemented since 2019 to support the local transportation service. Shobara is one of the target regions of "Smart Mobility Challenge 2019", the new project started by the Ministry of Economy, Trade and Industry (METI) and MLIT.

Shobara MaaS offers following services in a depopulated area:

1. AI on-demand-responsive transportation service that combines daily living and tourism transportation in areas with no public transportation,
2. Green Slow Mobility (GSM) service for tourists within touristic areas,
3. Introducing a web application experiment that provides centralized travel itineraries and tourism information.

This study focused on the AI on-demand bus (Figure 4.4) service of Shobara MaaS which offers a demand bus system using AI and a "subscription (unlimited ride)" fare. The AI on-demand shuttle bus runs on a semi-scheduled route in those selected areas, and users can make reservations through a dedicated phone app or the call center. To use the service, passengers need to make an advance reservation through either a phone call or a mobile application. The reservation needs to be made approximately one hour before the scheduled pick-up time. While AI technology has the potential to generate more accurate routes based on passenger preferences and improve the overall performance of transportation services, it may not be effective in rural areas with low demand, resulting in dysfunctional AI operations and limited benefits for passengers in such areas. Despite this, the cost of the AI on-demand service varies by location, and it is more affordable than traditional buses and taxis. In addition, AI on-

demand provides a monthly subscription option that is not available with other transportation modes.

The fare of the service is different for each area:

From Kanda Yashita to Gohara to Tojo city area

One-way: 310 yen, unlimited rides for one month: 2,400 yen

From Kamiyadani to Goya, from Chikayayadani to Kuyoshita to Tojo city area

One-way: 210 yen, unlimited rides for one month: 1,600 yen

From Zujyu garage to Zujyu to Tojo city:

One way: 410 yen, unlimited rides for one month: 3,200 yen

Figure 4.4. AI on-demand shuttle bus

Toei supermarket is the largest supermarket in Tojo town and provides a highly convenient waiting space for older shoppers and have access to the AI on-demand bus stops. The waiting space is situated within the supermarket and offers access to important information, such as bus schedules and IC card charging facilities, as well as comfortable benches for resting (Figure 4.5, 4.6). Overall, there are more AI on-demand bus stops compared to regular route buses, and the service area is also expanding. Therefore, you can ride closer to your home or destination than ever before.

Figure 4. 6 AI demand shuttle bus stop

Figure 4.5 Waiting space at Toei

4.3.2 MaeMaaS, Maebashi

Socio-economic background

Maebashi city is located in Gunma Prefecture, which is a part of the Kanto region of Japan. As of 2020, the city had an estimated population of 335,352 people. The city's population has already entered a declining phase, if the population continues to decline at its current rate, it will reach 275,657 in 2045 according to estimates by the National Institute of Population and Social Security Research (IPSS). In terms of socio-economic background, Maebashi is a mix of urban and rural areas, with a relatively high level of economic development compared to other parts of Gunma Prefecture.

Maebashi City has a well-developed system of schools, including both public and private institutions at all levels. The city is also home to several universities and colleges, including Gunma University and Maebashi Institute of Technology. The city has a diverse economy, with major industries including manufacturing, healthcare, and services. While the city has a relatively high level of economic development, it also faces challenges related to poverty and social inequity, particularly in rural areas.

Overview of urban and transportation developments plans

The JR Joetsu Line runs through the western part of the city, while the JR Ryomo Line runs through the southern part of the city, providing access to Takasaki and Tokyo. Maebashi and Shin-Maebashi stations have a high concentration of users, while Chuo-Maebashi and Ogo stations has a limited use. A radial bus network has been formed from the central area to the suburbs, but except for some routes, the frequency of each line is low, and there are concerns that the network's function as a means of connecting between regions is insufficient (Maebashi city, 2021). However, the number of bus routes connecting to the Shinkansen station at Maebashi is fewer than those at Maebashi Station, which makes the network structure more supportive of access to areas outside the city such as Takasaki.

Additionally, community buses (Mybus) operate around Maebashi and Shin-Maebashi stations to circulate in the city centre. Mybus has four routes from the city center to four different directions. Although there are 10 taxi companies in the city providing door-to-door individual transportation, the number of passengers using this service has been decreasing.

Current mobility issues

Like many other mid-sized cities in Japan, Maebashi has problem of increase in financial burden on municipalities to maintain their public transport and increase in traffic accidents caused by elderly drivers. Maebashi city stated that the accessibility to the city center from the suburbs is poor therefore, needed new transport systems to improve the accessibility level. It is also mentioned that the opportunities to travel are limited in areas with no public transportation.

In areas outside of urban regions with limited transportation access, it is necessary to introduce transportation services that are tailored to the specific mobility demands of the area, without being limited by traditional bus routes. There are still some transportation-inaccessible

areas remain despite operating demand-response transport services such as Furusato Bus, Runrun Bus, and Jonan Aozora-go.

Overview of MaeMaaS MaaS

With the support of the Ministry of Economy, Trade, and Industry (METI) and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Maebashi has introduced a MaaS system called MaeMaaS (Fig 4.7). This system aims to enhance the convenience of local transportation and restructure the city's transport network.

MaeMaaS is designed to improve the overall transport convenience by integrating all public transportation with shopping facilities, enabling searchability, booking, and payment of all public transport routes through a single platform. This integrated system is expected to increase the attractiveness of visiting the central city area, promote sustainable mobility, and enhance the overall quality of life for citizens. Since its launch in September 2021, MaeMaaS has already registered around 2,500 members as of March 2022. This positive response from the community shows that the system is successfully addressing the transportation needs of the local population while simultaneously providing an enhanced and streamlined travel experience.

Figure 4.7 MaeMaaS bus

MaeMaaS services include the following:

- Implementation of various simulations and fare pool distribution for joint management of bus routes
- Provision of real-time route search using open data
- Route search (bus locator, shared bicycle, on-demand transportation, etc.)
- Sales of digital free passes
- Provision of discounts for Maebashi citizens based on citizen authentication card (my number card)
- Provision of a search function for local tourist facilities and restaurants
- Benefits at shops for purchasers of digital free passes for local buses

4.3.3 Shizuoka MaaS

Socio-economic background

Shizuoka is a city located on the south coast of Japan and serves as the capital city of Shizuoka Prefecture. According to estimates from 2020, the population of the city is approximately 704,000 people (Shizuoka City Statistics, 2022). Shizuoka is the 5th largest city in Japan in terms of geographic area.

The city has a diverse economy with a range of industries, including manufacturing, agriculture, tourism, and services. The manufacturing sector in Shizuoka City is particularly strong, with a focus on producing electronic and transportation equipment.

Overview of urban and transportation developments plans

One of the major transportation developments in the city is the introduction of a new high-speed train line, the Tokaido Shinkansen, which connects Tokyo to Osaka and stops in Shizuoka city. This has significantly improved the connectivity of the city with the other major

metropolitan areas in Japan. Shizuoka Station, which serves as a major transportation hub connecting the city to other areas in the region, has operated by JR central (Shizuoka city). Shizuoka city has 2 train lines, 46 bus lines and 146 taxi companies.

In 2014, “Act on Revitalization of Local Public Transportation” was revised to clarify the current situation, problems, and issues of local public transportation. The aim was integrally forming and sustaining the public transportation network as a whole. Therefore, “Regional public transportation network formation plan” was created, to create in compact town development, improve the cooperation between the state of public transportation and the administration of the entire region.

In recent years, the city has been making efforts to promote sustainable transportation options including bike-sharing system, the city has also been expanding its network of pedestrian-friendly zones. These efforts aim to reduce the car-dependency and promote more environmentally friendly modes of transportation. Furthermore, the city has hilly and mountainous areas to cover and maintaining and strengthening local communities in those areas is crucial.

Current mobility issues

As same as other case studies, public transportation is facing challenges due to increasing car usage, a rapid decline in population and birth-rate, and an aging society. The bus networks are experiencing a decline, and if the service standards continue to worsen, there will be a further decrease in the usage of public transportation. With the increasing number of elderly people surrendering their driver's licenses, it is necessary to seek alternative means of transportation that do not rely excessively on private cars. However, there is also a decline in transportation services due to a shortage of bus and taxi drivers.

The problem at hand is the challenge of maintaining and strengthening local communities while addressing various needs such as securing means of transportation for the elderly, creating opportunities for social activities, and increasing populations that contribute to the sustainability of the region. Additionally, promoting the visits to the city center, shopping districts, and around station areas are important to create liveliness in the city. However, the issues of public transportation vary from region to region. It is necessary for local governments, which are in charge of comprehensive administration of the region, to play a central role in cooperating with business operators and promoting the formation of sustainable public transportation networks as part of regional strategies.

Overview of Shizuoka MaaS

Shizuoka MaaS Demonstration Project launched on May 27, 2019, to provide new mobility services that are easy to use for everyone using the latest technologies, such as ICT and AI. Shizuoka MaaS is community-based public-private partnership consortium with the aim of creating a sustainable city that utilizes. Shizuoka MaaS operating areas include the Tamagawa area, Shizuoka City in Shizuoka Prefecture (a mostly hilly and mountainous area), and areas along the Shizutetsu train lines. They aim to promote the activities of local residents in those hilly and mountainous areas while planning to improve the living environment in those areas using digital technology.

An AI on demand bus system is implemented, where the MaaS service links different transportation modes such as trains, buses, and taxis. Demonstration of AI-assisted taxi service aims to complementing the first/last mile transportation from train stations and bus stops. Additionally, they also focusing on investigating the possibility of collaborating with commercial facilities such as shopping malls, restaurant, and hospitals to explore the potential for public transportation marketing.

Shizuoka MaaS services include the following:

- Linkage between different modes of transport such as railways, buses, and taxis
- Route search for railway and buses
- Free demonstration of AI on-demand transport operation with the participation of residents
- Functionality that allows the booking of AI on-demand transport easily
- Creation of livelihood support services (e.g., remote shopping support using smart glasses)
- Content for travellers (e.g., local events such as veranda cafés) and linkage with transport services
- Coupon distribution according to railway usage times and personal characteristics

4.4 Applicability of the study

Even though the study was conducted with three MaaS cases, most results are relevant to other MaaS cases. Table 4.1 summarized some MaaS projects in Japan and we classified MaaS cases with its specific targets users, objective, area type, and expected change in travel behaviour. As we discussed earlier many MaaS projects were in cooperation with tourist facilities while securing and maintaining local transport. The recent trends in the market are more in-line with cooperation with commercial facilities to provide integrated services. This study examined all the leading and MaaS examples that has been chosen by the MLIT in Japan and compared the similarities and differences among the cases. There are over 150 MaaS projects that are publicly awarded by the Japanese Government within the Smart Mobility Challenge Initiatives since 2019. Also, there are 31 proposals under the Super City Initiative which was launched to connect local governments with technology companies in 2019. MaeMaaS named as one of them and their people-centered services and infrastructure such as

“Maebashi ID” and “mobile information network” that ensure security centralized the concept of “no one left behind”.

We analyzed the contrast of similarities and differences of MaaS objective, their target people, and geographical area type. The prioritization of our case study was to focus on MaaS that aims to maintain the local transport and town developments rather than sustaining or harmonizing tourist.

We chose to study Shobara MaaS because the present study focuses on a rural region in Japan that has experienced a significant decline in population, resulting in an inefficient local transport system. Additionally, the study seeks to draw insights from a successful case study with a 2–3-year history. At the same time, Shobara faces unique geographical challenges in providing transportation services including a vast area to cover and mountainous terrain. The experience of Shobara in addressing these challenges could be useful for other similar cases, particularly in areas with challenging geography or sparse populations.

We chose case studies to represent the two types of institutional organization structure of MaaS projects: private industry development and government development. Therefore, we narrowed possible case studies into two representative MaaS cases. Two case studies allow us to study how two different institutional organization structures of MaaS developments addressed equity impacts and implications in their respective projects. Thus, we analyzed these two leading MaaS projects that can be considered successful and were operated since MaaS began implementation in Japan. We also aim to choose MaaS cases that can represent other cases looking at future equity implementation of similar MaaS projects. Both Shizuoka and MaeMaaS named as 38 new projects from the MLIT in 2020 with an aim to support regional characteristics

Sharing and learning from the experiences of these case studies could potentially inform and inspire more effective and efficient transportation planning and provision in other regions

facing similar challenges. The unique aspects of each MaaS cases and their differences leveraged to increase the generalizability of our findings.

Table 4.1 MaaS case studies

		Shobara	**Maebashi**	**Shizuoka**
Objective	In cooperation with tourist facilities			
	In cooperation with commercial facilities		✓	✓
	Maintaining local transport	✓	✓	✓
	Town development and community harnessing			✓
Target	Tourists			
	Elderly people	✓	✓	
	Residents			✓
Expected change in travel behavior	Shift from private cars		✓	✓
	Movement between cities or touristic places			
	Increase movement	✓	✓	✓
Area type	Remote areas	✓	✓	
	Regional and suburban areas			✓
	Urban areas			

CHAPTER 5

Spatial accessibility as an indicator measuring inequity.

5.1 Introduction

Several studies used accessibility as an indicator of transportation-related social equity. Pritchard et al. (2019) revealed that, from an equity perspective, one's access to an opportunity is more important than whether one chooses to use that access. Ryan and Pereira (2021) stated that the focus has shifted from the idea of mobility to the idea of accessibility over the last two decades. Fransen and Farber (2019) asserted that insufficient accessibility levels result in inequitable transportation benefits distribution, as certain people are unable to reach their desired activities and, therefore, unable to participate in society fully.

An inequitable society results in unequal access to education, employment, daily activities, and social interaction, thereby disabling citizens from being a part of society. Most social equity studies compared equity levels by ethical and racial groups; however, we consider age a disaggregation because of Japan's significant aging issue. Furthermore, this study focused not on transportation accessibility to and from work, as nearly all accessibility studies did, but on the accessibility of other essential locations, such as hospitals and shopping malls.

Our research determined whether new mobility services such as Mobility-as-a-Service (MaaS) can enhance social equity and accessibility levels, specifically for vulnerable groups in most need of aid. Methodologically, it used person- and place-based accessibility measures to calculate more detailed individual accessibility levels, which further allowed us to examine equity levels across different social groups. The Gini coefficient and Lorenz curve were later estimated based on both measurements to examine transportation-related social equity.

5.2 Shobara MaaS

A case study was conducted in Shobara, a city in Hiroshima, Japan, whose total population of 37,000 has decreased by 4,292 people (about 10%) in the 7 years since 2010. The aging population in Shobara is becoming more apparent, with 14,712 people or 43.9% of the total population aged 65 and over (Shobara City, 2021). In recent years, Japan has been facing serious natural disasters, such as torrential rain in western Japan, which caused a slope collapse on the Hiroshima-Kure Road and JR Kure line in July 2008. The JR buses were operating as a substitute for the JR Kure line, and because the buses did not support the information system, it created serious traffic congestion and difficulties in using public transport.

In addition, maintaining local public transportation has become a major challenge because of depopulation, the large coverage area, and the recent shortage of bus drivers. About 7,509 km of general bus routes were completely abolished in the six years from 2010 to 2015 Akagi et al. (2021). This led to a highly car-dependent population and the social exclusion of the aging society. Moreover, Akagi et al. (2021) stated that current bus routes are gradually failing to meet the needs of people traveling to hospitals, shopping malls, and other locations.

In Japan, the Ministry of Economy, Trade and Industry (METI) and MLIT jointly started the new project “Smart Mobility Challenge” in June 2019. They selected 52 target regions for demonstration tests aiming to support regional areas and companies in solving mobility and vitalization challenges in such areas by implementing new mobility services, and Shobara is one of the target regions. The AI on-demand shuttle bus has started operating under the name of Shobara MaaS, even though it has not fully integrated with the existing buses and other modes. However, these trials would help planners proceed to fully integrate MaaS. The AI on-demand shuttle bus runs on a semi-scheduled route between Shobara’s Honmura and Mineta areas and its city center. It improves daily transport, creates a transportation network to enable people, mainly the elderly, to go out more frequently to increase interaction opportunities with

locals, and provides transportation for those who can no longer drive. AI technology would aid in generating more accurate routes with better predictions based on passenger preferences; however, demand in rural areas is considerably low, possibly resulting in dysfunctional AI operations.

5.3 Calculation of accessibility measures

This study used both place- and person-based accessibility measures because the former fails to address accessibility on a more detailed and individual level. In this study, the cumulative opportunity measure was calculated by the formula below (1), which counts all services within a given travel distance, time, or cost threshold (Lucas et al., 2016). Place-based accessibility attributes the same extent of accessibility to every individual in a zone, regardless of personal preferences for travel (El-Geneidy et al., 2016). We counted the number of groceries and hospitals available within a 15 min travel time at a grid cell level separately.

$$A_i = \sum_{j=1}^{J} B_j a_j \tag{1}$$

where,

A_i = Accessibility measure at point *i* to potential activity in zone *j*

a_j = Opportunities in zone *j*

B_i = A binary value equal to 1 if zone *j* is within the predetermined threshold and equal to 0 otherwise

Izumiyama et al. (2007) discovered that a wide range of constraints is imposed on the elderly's participation in out-of-home activities, such as physical disadvantages, maintenance of daily lifestyles for their health and entrenched habits, limited space-time areas of activity

engagement for both safety problems and limited information acquisition ability, and monetary budget constraints.

Two major inputs were needed to measure space-time accessibility. First, we created time budget, also defined as a time window. A time window is defined as a time budget corresponding to available locations between two consecutive fixed activities in an individual's daily activity program (Kim, 2018). The series of time windows were made from an individual's travel survey data. As activities occur in different areas during various times of day, distinguishing activity types was complex. Nevertheless, each respondent's time window was calculated separately.

Second, space-time accessibility was calculated by counting the activities satisfying the temporal constraints, as seen in the formula below (2). It has been used to calculate each nonwork activity separately.

$$SPT_{i\_m} = \sum_{w} \sum_{j} O_j' \tag{2}$$

where,

SPT_{i_m} = Space-time accessibility of individual *i* by travel mode *m*

O_j' = The number of available activities under the temporal constraints

w = A set of daily time windows of individual *i*

Ryan and Pereira (2021) stated that far fewer studies adopt a person-based approach, partly because of the data and computational challenges involved. In this case study, all sleep-, work-, education-, and health-related activities were considered fixed. We made simple assumptions based on the activity type to calculate time windows. For example, if a person goes to work, visits a hospital, goes shopping, returns home, and sleeps, the person has four travel time windows, excluding shopping, because it is not a fixed activity.

5.4 Measuring transport equity

As stated in previous chapter, the main task of assessing transportation equity is determining the definition itself and choosing which metrics, indicators, and measures to use. This study considered three key components of measuring transportation equity (Table 5.1).

1. Specification of distributed benefits or costs. The first step in transportation equity assessment had four key dimensions: (a) mobility/accessibility, (b) traffic-related pollution, (c) traffic safety, and (d) health, as stated in Martens et al. (2019). This study focused on the mobility/accessibility dimension. We considered three different focal variables to define the benefits or costs generated by transportation for this dimension. The first variable, resources, referred to differences in an individual's resources or possessions, including access to different transportation means, particularly cars. The second focal variable was opportunities or having a specific resource. Whether an individual can reach their important daily activities depends highly on personal characteristics, physical and cognitive abilities, and financial resources. Third and last, outcomes described the benefits and costs obtained using resources and opportunities.

2. Differentiation of population groups. Assessing the fair distribution of transportation benefits is essential in equity matters. Ethnicity is currently a key factor in the differentiation of population groups because most recent equity studies are conducted and started in Western countries. However, we distinguished population groups by age, the most important factor for transportation equity discussions in the Japanese context. Furthermore, gender plays a crucial role in transportation equity because women and men have different mobility needs and patterns. Household size was also considered a key distinguisher in assessing transport accessibility differences and engagement in out-of-home activities. The study also considered driving and daily physical ability, which are firmly correlated to access to opportunities. Therefore, we examined whether there is an accessibility level difference between people who

feel worried about driving ability and people who feel concerned or worried about daily movement after 10 years.

3. Selection of equity principles. There were several possible principles to assess the fairness of a situation. Ethical principles, more specifically egalitarian and sufficientarian theories, can underlie equity principles. These theories can explicitly be linked to the Gini index or coefficient. Lucas et al. (2016) revealed that the significant benefit of the Gini coefficient over other equity indices is its scale independence. It assesses whether something (e.g., accessibility) has equal distribution among the population, with 0 meaning equity and 1 meaning inequity. Delbosc and Currie (2011) explained that the Lorenz curve visually represents equity, while the Gini coefficient represents the overall degree of inequity using mathematical metrics. In other words, it yielded a different measure of inequity to describe accessibility distribution among various population sectors.

Table 5.1. Indicators for measuring transportation equity

Focal variable	**Possible equity measure**	**Possible utilization**
1. Resources	Ownership of transportation means	Average no. of private vehicles and bicycles in a household
	Walkability	Areas within a 10–15 min walk
2. Opportunities	Access to health services	No. of hospitals that can be reached within a 15 min travel time
	Access to shopping malls	No. of shopping malls that can be reached within a 15 min travel time
3. Outcomes	Travel time	Travel time to basic opportunities by each mode
	No. of activities	Average no. of out-of-home activities

5.5 Data collection

The study focused on the city center and other areas covered by the AI on-demand shuttle bus to obtain the number of grocery stores and hospitals within a 15 min travel time. Previous studies used predetermined travel times of 15 min, 30 min, 45 min, or 60 min for their cumulative opportunity measure. A 15 min travel boundary was used in this study because the travel in Shobara can be covered in a given short period. Furthermore, we excluded the waiting time for public transportation; instead, the shortest travel time between the origin, the zone centroid for each origin zone, and the destination is calculated for each mode. The travel times for public transport were extremely optimistic, which was the limitation of our study. We used a grid square system with an aerial distance of 1 km between centroids and counted the number of activity opportunities in every grid cell by different transportation modes. The population of each grid cell was obtained from the 2015 National Census of the Ministry of Internal Affairs and Communications (MIC) Statistics Bureau.

Place-based accessibility for hospital accessibility was significantly low and centralized in the city center. Figures 5.3–5.6 show the grocery shopping accessibility levels of grid cells in Shobara, according to the place-based measures of four different transportation modes: bus, car, walking, and AI on-demand shuttle bus, respectively. We excluded the figures for hospital accessibility for brevity and in adherence to the word limitation. As Fransen and Farber (2019) mentioned, the highest quintile in accessibility levels consists of areas with high population densities and many opportunities, and grid cells provide an overview of the accessibility level in a study area. However, this measure fails to determine who actually benefits. Therefore, person-based measures were conducted to show individual accessibility levels.

In Japan, person-trip data was often only collected from urban areas, leading to the lack of data and opportunities for transportation studies in rural areas. Fortunately, Shobara developed a simulation system with a MaaS Tech Japan company and obtained trip pattern data from

MLIT because of the emerging need for a database. The survey was conducted in the entire Hiroshima area with 255 participants obtained from NITAS, developed by MLIT. A random sampling approach was used, but we eliminated citizens outside the study area. Therefore, the number of trips was only 52, another limitation of this study. The database contained self-reported trip patterns with the trip frequencies, distance, and travel times of 12 travel destinations, along with the most used transportation modes. The travel survey also asked personal activity–related questions, such as whether the respondents feel worried when driving and whether they feel concerned or worried about their daily movement after 10 years. Their answers were used to compare space-time accessibility measures in the next section.

As the number of elderly people rises in rural Japan, access to health care becomes an even more important issue. Moreover, the "kaimono nanmin" phenomenon referring to "shopping refugees" is evolving as a severe problem in Japan. In 2008, Sugita (2008) reported the issue of the nation's increasing older population who lack access to shopping facilities, such as department stores. Therefore, this study examined the accessibility of shopping and health-care activities as important daily opportunities in Shobara. The following data analysis was from survey data obtained by MLIT, which will be explained in detail in the next chapter. Figures 5.1 and 5.2 show the most used transportation modes in the main two activities in Shobara. Over 89% of people use cars to visit shopping malls and hospitals, demonstrating that car dependence is exceptionally high. Moreover, Tables 5.2 show travel frequency for shopping and health-care activities, indicating that more people attend shopping than health-care activities. Most of the respondents (36) revealed that they go shopping 1–2 times a week, followed by 29 respondents who went shopping less than once a month. In contrast, 27 respondents did not go to the hospital, while 20 went less than once a month.

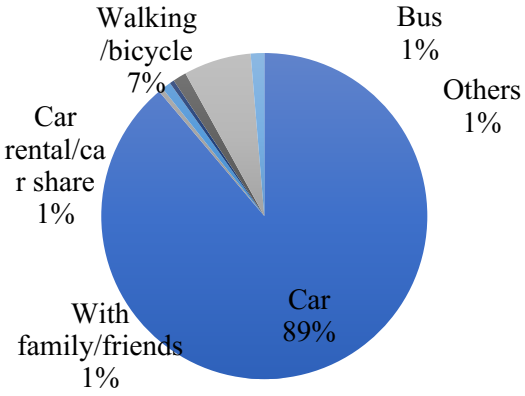


Figure 5.2 Most Used Transportation Modes to Go to the "Shopping"

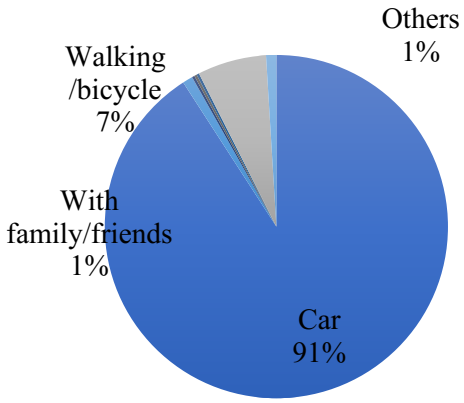


Figure 5.1 Most Used Transportation Modes to Go "Hospital"

Table 5.2 Number of Nonwork Activities

	No. of Shopping Activities	No. of Health-Care Activities
Every day	2	0
5–6 times a week	1	0
4–3 times a week	10	0
1–2 times a week	36	1
Once in two weeks	16	2
Less than once a month	29	20
Not at all	6	27

5.6 Use of Gini coefficient

After identifying the place- and person-based accessibility, the next step was determining the accessibility distribution between different population groups and areas. A higher Gini coefficient indicates greater inequity, with a value of 1 meaning perfect inequity, whereas a value close to 0 indicates greater equity.

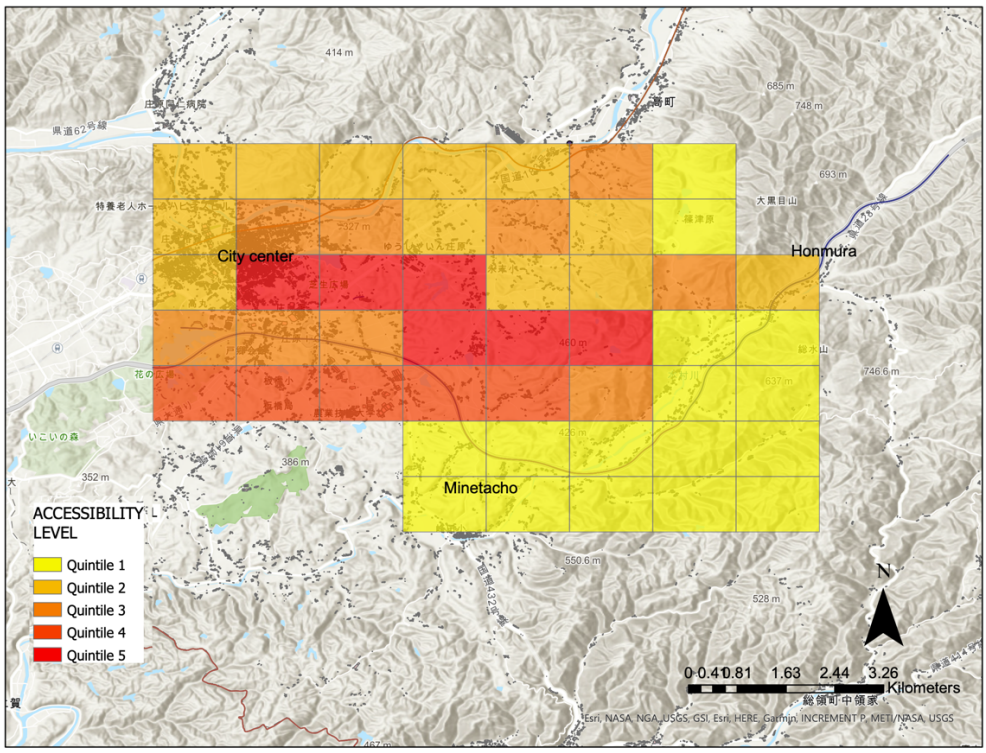


Figure 5. 3 Place-Based Grocery Shopping Accessibility Level by Bus at Grid Cell in Shobara (Organized from Low Accessibility [Quintile 1] to High Accessibility [Quintile 5])

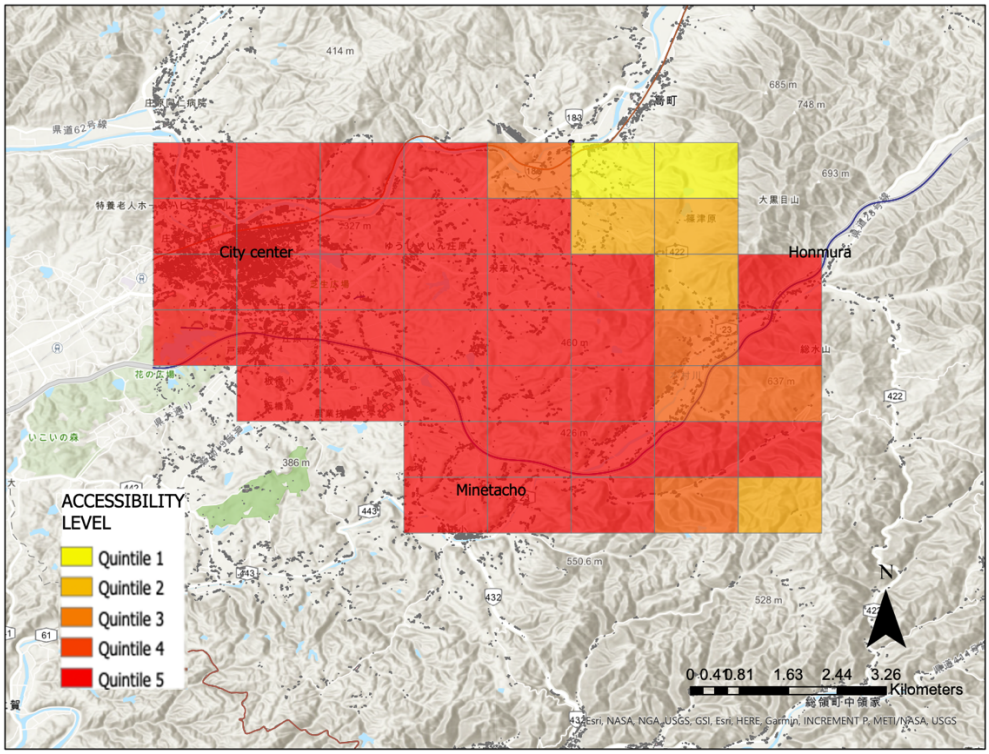


Figure 5. 4 Place-Based Grocery Shopping Accessibility Level by Car at Grid Cell in Shobara (Organized from Low Accessibility [Quintile 1] to High Accessibility [Quintile 5])

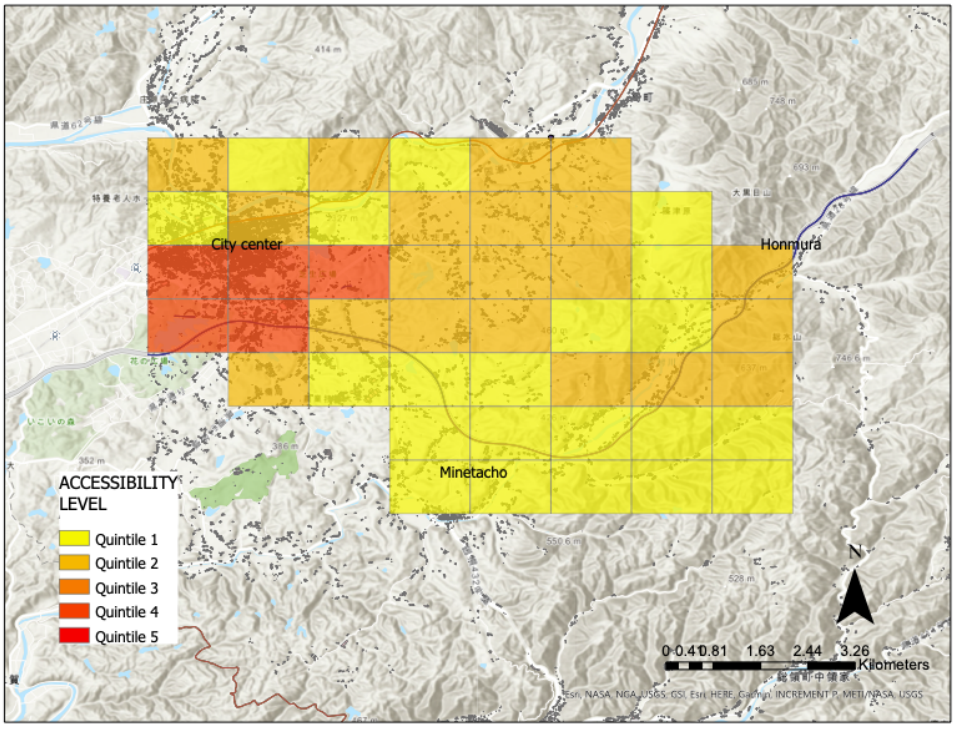


Figure 5.5 Place-Based Grocery Shopping Accessibility Level by Walk at Grid Cell in Shobara (Organized from Low Accessibility [Quintile 1] to High Accessibility [Quintile 5])

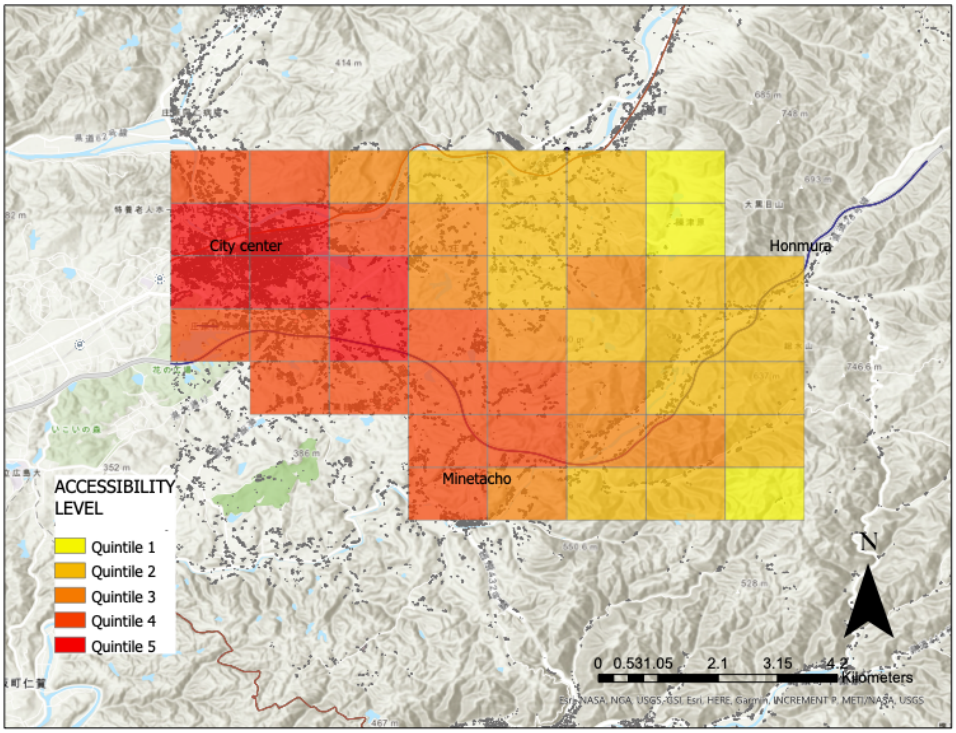


Figure 5.6 Place-Based Grocery Shopping Accessibility Level by AI On-Demand Shuttle Bus at Grid Cell in Shobara (Organized from Low Accessibility [Quintile 1] to High Accessibility [Quintile 5])

The following was the formula used to yield the Gini coefficient (Delbosc and Currie, 2011):

$$G_1 = 1 - \sum_{k=1}^{n} (X_k - X_{k-1})\,(Y_k + Y_{k-1}) \qquad (3)$$

where,

X_k = Cumulated proportion of the population variable for $k = 0, \ldots, n$, with $X_0 = 0, X_n = 1$

Y_k = Cumulated proportion of the accessibility variable for $k = 0, \ldots, n$, with $Y_0 = 0, Y_n = 1$

The Gini coefficient was calculated for both place- and person-based accessibility measures with different travel modes, including a car, bus, and AI on-demand shuttle bus. In other words, it measured the accessibility levels of distinguished regions and different groups of people (Yeganeh et al., 2018). Walking involves many physical aspects of access, from walking certain distances or within unsafe neighborhoods, especially for vulnerable people. Burton and Mitchell (2006) state that elderly people are inclined to walk shorter distances than younger people, with their comfortable distance at around 500 m.

Alves et al. (2020) studied the correlation between various levels of physical exercise, walking speed, and 500 m walking time and introduced two different types of speed with low-speed walking (2.16 km/h) and normal speed walking (3.42 km/h). Hence, this study used two different walking time coefficients for 10 and 15 min.

5.7 Results and discussion

5.7.1 Place-Based Measures

The Lorenz curves for the tested accessibility measures are shown in Figure 5.7. The most equal distribution of grocery store accessibility was provided by cars, with a low Gini coefficient (G = 0.247) that was almost a quarter of the resulting bus coefficient. Of course, this could only be achieved by those with access to cars. The accessibility level provided by a bus was not as equally distributed among the Shobara population (G = 0.721).

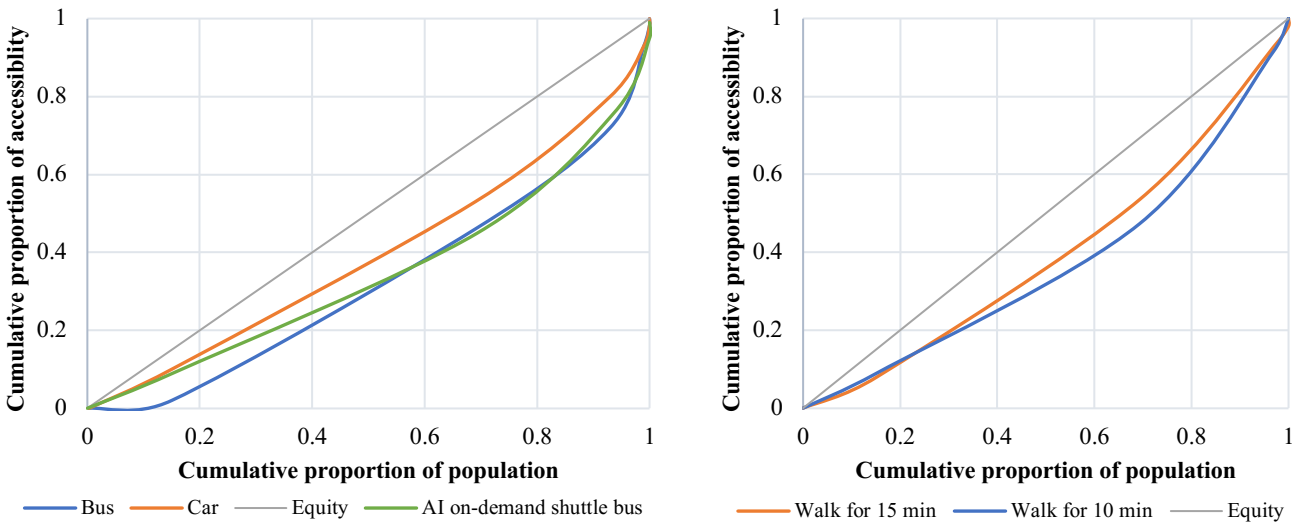


Figure 5.7 Lorenz Curves for the Considered Place-Based Accessibility Measures to Grocery Stores

In contrast, the accessibility level of the AI on-demand shuttle bus was better distributed among zones (G = 0.368). Meanwhile, the accessibility distribution of walking for 15 min (G = 0.276) was slightly less equitable than walking for 10 min (G = 0.310).

As shown in Figure 5.8, a similar result can be observed for hospital accessibility, where cars had the most equal accessibility distribution (G = 0.244). The accessibility level provided by buses was also not equally distributed among the Shobara population (G = 0.568). The AI on-demand shuttle bus provided the next equal hospital accessibility distribution (G = 0.27). Furthermore, walking had a more equitable accessibility distribution, and the accessibility distribution of walking for 10 min (G = 0.302) was slightly less equitable than walking for 15 min (G = 0.291).

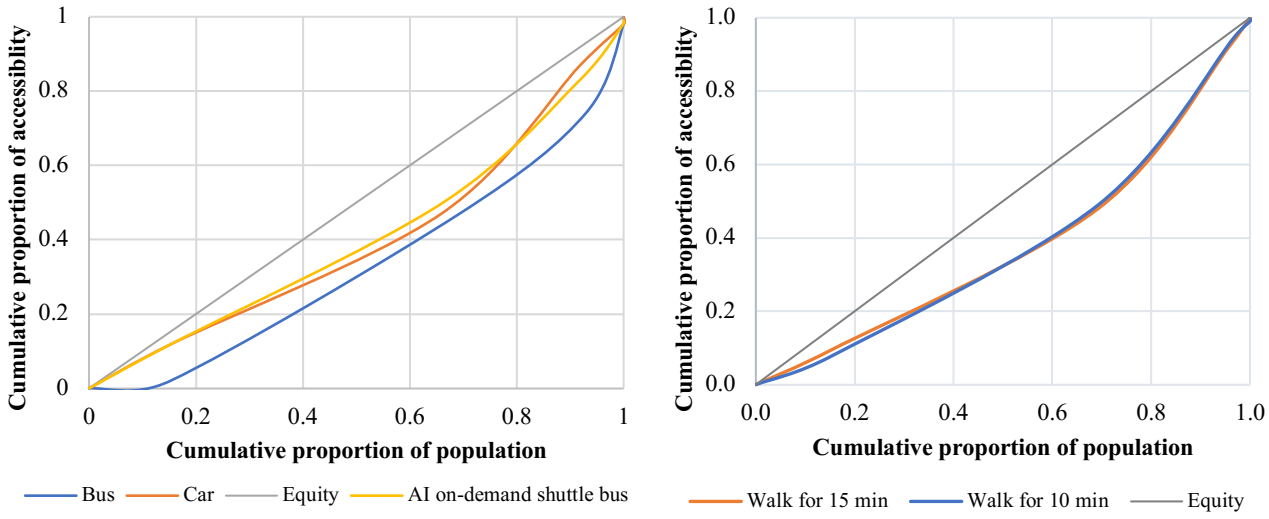


Figure 5.8 Lorenz Curves for the Considered Place-Based Accessibility Measures to Hospitals

5.7.2 Person-Based Measures

In terms of person-based accessibility, we calculated space-time accessibility measures for those participating in a health-care activity. The Gini coefficient produced a higher value than place-based measures, with its score of 0.32, showing car accessibility to be more equitable. The Lorenz curve (Figure 5.9) implied that Shobara residents experience severe public transportation–related social inequity issues compared to car accessibility (G = 0.61). In contrast, the AI on-demand shuttle bus had a lower Gini coefficient value relative to the bus, showing a high level of accessibility (G = 0.43). The accessibility level of a 15 min walk was not equally distributed (G = 0.38) compared to place-based measures, whereas the 10 min accessibility was considerably less equitably distributed with a score of 0.46, demonstrating that walking was highly inequitable among individual Shobara citizens.

A more detailed way to show the accessibility levels of specific population groups is by measuring individual accessibility levels. We measured the average accessibility level by different population groups because we measured individual accessibility levels. Space-time accessibility measures were used to measure differences in accessibility for various

sociodemographic groups (Table 5.3). This study highlighted the relationships between accessibility and multiple sociodemographic characteristics. The people-based measure's result indicated significant differences within the different groups. For example, there was a substantial accessibility level difference between age groups, suggesting older people have less access to each transportation mode. The accessibility level decreases with age; the following table compares the accessibility levels of various population groups.

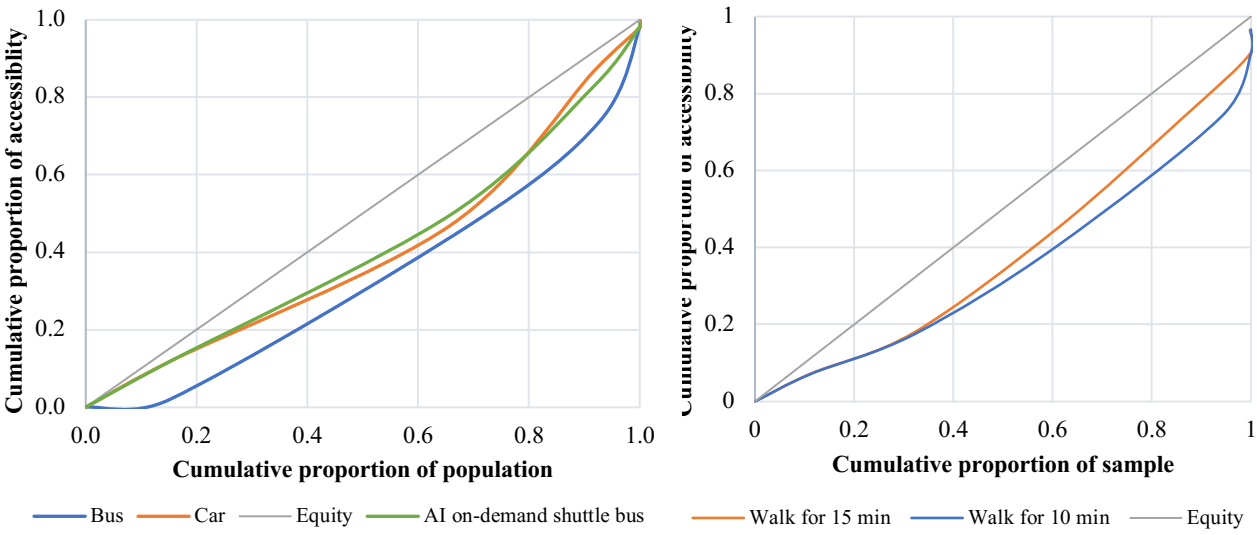


Figure 5.9 Lorenz Curves for the Considered Person-Based Accessibility Measures to Hospitals

Gender

Analysis of the accessibility of various transportation modes indicates that the difference between men and women was insignificant. Women's access to a car and the AI on-demand shuttle bus was found to be slightly higher than that of men. However, their access to a bus and walking was lower than that of men.

Age

Compared to the 18–34 age group, the 55–74 age group had significantly lower accessibility. However, the 35–54 age group had higher accessibility than the 18–34 age group. Car

accessibility among all age groups was higher than other transportation modes, followed by the AI on-demand shuttle bus and regular bus. Moreover, the walking accessibility level was exceedingly low for the elderly, attributable to their physical activity and movement.

Household

Compared to individuals living alone, those living with a spouse had a significantly higher accessibility level of 37%. Those living with children had a level of 24%, and those living with their parents had a level of 26%. Accessibility level by car and walking was lowest for people living alone, which can be attributed to less engagement in out-of-home activities and a smaller travel budget. This result implied that people living alone have a high inequitable accessibility distribution.

Feeling worried about driving ability

Overall, the accessibility level was not as different for people who feel worried about when they drive, whose accessibility level was significantly lower. Interestingly, access to the AI on-demand shuttle bus was considerably higher than other transportation modes.

Feeling concerned or worried about their daily movement after 10 years

A similar result to the above was observed. Walking accessibility was considerably related to daily physical activities; therefore, the accessibility level was low. In addition, bus accessibility had the same effect as walking, whereas there was no substantial accessibility level difference between a car and the AI on-demand bus.

Table 5.3 Person-Based Accessibility Levels

		Ratio	Car	Bus	Walk	AI on-demand shuttle bus
Gender	Male	40.6%	36.9	23	11.8	32.7
	Female	59.4%	41.5	20	10.2	34.2
Age	18–34	34.4%	41.5	24.5	13.8	38.5
	35–54	45.7%	39.1	17	11.4	27.6
	55–74	21.9%	37.7	14	8.4	24.7
Household	With spouse	37%	42.1	22.7	12.4	37.6
	With children	24%	45.5	27.4	16.6	37.1
	With mother/father	26%	39	17.9	8.5	32.2
	Living alone	13%	38	23.5	9.4	28.8
Feeling worried about driving ability	Yes, I do	18.7%	40	19.5	5.6	37.5
	Neither	21.9%	39.4	13.6	6	27.7
	Not so much	59.4%	39.6	23.7	12.7	33.3
Feeling concerned or worried about their daily movement after 10 years	Yes, I'm worried	25%	40	18	7.8	33.6
	Neither	25%	39.4	26.2	10.9	33.2
	Not so much	50%	39.6	20.4	12.1	33.8

5.7 Summary

This study revealed variations of social equity assessment methodology among social groups and investigated how MaaS improves equal accessibility distribution for nonwork activities in rural areas of Japan.

The main task of assessing transportation equity was determining equity with metrics, indicators, and measures specific to Japan's rural areas. This study considered three key steps for evaluating transportation equity: determining the distributable benefit/cost, discovering the differentiation of population groups, and selecting equity principles. We defined the resource, opportunity, and outcome indicators according to the case study condition to determine the distributable benefit and cost.

As 42% of Shobara's total population is over 65 years old, healthcare access is becoming a significant challenge. Moreover, the *kaimono nanmin* phenomenon, referring to "shopping refugees," explained the issue of an increasingly older population lacking access to shopping facilities. Therefore, this study chose healthcare and shopping activities as vital out-of-home activities in Japan's rural areas. Over 89% of people used a car to go to shopping malls and hospitals, demonstrating that car dependency is excessively high in Shobara.

The analysis of person- and place-based measures showed that car accessibility remains higher than other transportation modes. The most equal accessibility distribution was provided by a car across different groups of people. Furthermore, the elderly had less access to transportation modes than young and middle-aged people, and the accessibility level provided by a bus was not equally distributed among the Shobara population. Nevertheless, the provision of the AI on-demand shuttle bus resulted in a remarkable decrease in the accessibility inequity of two out-of-home activities compared to a regular bus and seemed to benefit almost all Shobara areas.

This study focused on equity outcomes of accessibility in certain regions. The place-based accessibility measure successfully showed where accessibility levels are high and low on a map and provided an overview of accessibility levels. In contrast, the person-based accessibility measure highlighted the relationships between accessibility and multiple sociodemographic characteristics. Furthermore, the results highlighted the importance of

implementing MaaS services, such as the AI on-demand shuttle bus, in rural areas to provide a more equal distribution of transportation benefits.

CHAPTER 6

Well-being through social equity framework

6.1 Introduction

In the transport sector, the need to assess social equity has become more evident, and efforts have been extended to study social isolation, well-being, quality of life, and opportunities and resources access. Mobility is a facilitator of well-being (Nordbakke & Schwanen, 2014) and goes beyond the desire for independence, social connections, "normalness," and travel for its own sake (Musselwhite & Haddad, 2010). In other words, the lack of mobility limits out-of-home activities and reduces contact with friends and family, which may cause social isolation and a decrease in quality of life, life satisfaction, and, most importantly, well-being (Jackson et al., 2019; Musselwhite & Haddad, 2010).

(Gilroy, 2008) pointed out that a supportive neighborhood with good access to local shops, facilities for older people and transport and 'the ability to get out and about' promoted well-being in old age. Furthermore, several studies have addressed that older people who have to give up driving tend to engage less in out-of-home activities and especially in 'discretionary' activities such as visiting friends or enjoying nature (Ziegler & Schwanen, 2011).

However, the connections between mobility and well-being are mainly conceptual, and little empirical evidence is available in the literature (J. Cao, 2013). To our knowledge, no prior work has examined well-being through the lens of transport equity. Transport policy makers have begun to associate the ability to be mobile with having a role in the facilitation of social inclusion. However, the further connection to well-being is not as well understood (J. K. Stanley et al., 2011). Therefore, there is a need to study whether different population groups especially older people are equitably experiencing transport or not besides if a new type of

mobility system especially AI on-demand bus which has been studied in this paper can enhance well-being in later life.

A primary aim of the present study is to investigate older people's unmet travel needs and satisfaction with different out-of-home activities. A secondary aim is to determine the correlation between four measures of satisfaction with out-of-home activities and life, freedom to go out, and social isolation with well-being in later life. Lastly, analyze the well-being measures from an equity perspective and explore if AI on-demand bus can possibly contribute to it. Shobara MaaS is on a trial stage hence, data on frequency usage of AI on-demand bus is limited. However, we explored several investigations on the user's experience as well as impact on number of out-of-home activities.

We analyze data from travel survey of Shobara citizens during the AI on-demand bus implementation in which measures are obtained of frequency of travel, activities that they want to do more, satisfaction with activities as well as life, social isolation, whether they are in need of help to perform out-of-home activities freely and independently. We directly interviewed older people to ask them if they need help performing out-of-home activities and why they refrain from going out. Social isolation was computed by incorporating marital status; frequency of contact with friends, family, and children; and participation in social activities. This study used Structural Equation Model (SEM) in order to understand the correlation of well-being variables. Later then four variables of well-being compared with different population groups.

6.2 Mobility and Well-being

Dimensions of well-being

In previous studies, well-being was identified by different dimensions such as objective or subjective, hedonic or eudaimonic, and universalist or contextualist. (Nordbakke & Schwanen,

2014) concluded that it is important to consider both the objective and the subjective and the hedonic and eudaimonic dimensions of well-being and pay detailed attention to the multiple ways in which well-being and its linkages to mobility are context-dependent and shaped by the particularities of time and place.

Subjective and Objective well-being

SWB is one influential perspective of well-being, and it has been recognized in the transportation context. For instance, some studies examined the influence of out-of-home activities and travel satisfaction on SWB (Bergstad et al., 2011; Ettema et al., 2010) and used it in the context of transport disadvantage and social exclusion (Delbosc & Currie, 2011; J. K. Stanley et al., 2011).

On the other hand, 'objective accounts' of well-being, life satisfaction, or even happiness, are not the whole of well-being (Haybron, 2011). SWB covers different aspects of objective well-being: while objective well-being can cover easily measurable dimensions like income, consumption, health, education, and work, it is harder to identify objective measures of social connectedness, relationships, security, etc. (Gordon & Tanton, 2013). The majority of studies to date have been focused on subjective well-being and they have paid little attention to objective views of well-being, which emphasize the relation between objective well-being and transportation is understudied.

Hedonic and Eudaimonic well-being

Subjective components may furthermore be presented as hedonic or eudaimonic. The hedonic view is based upon the idea that well-being consists of experiences of happiness or pleasure through the satisfaction of preferences and that people will try to maximize their well-being (Ryan & Deci, 2001).

The hedonic stance follows the philosophical school of utilitarianism (De Vos et al., 2013; Nordbakke & Schwanen, 2014). In other words, hedonic is based upon the idea that a person's 'utility' is a measure of the happiness or pleasure that s/he experiences through the satisfaction of preferences, and that this happiness is the basis of her/his well-being (Diener, 2009).

On the contrary, well-being is more than preference satisfaction for eudaimonic thinkers, such as Aristotle. He emphasized purposeful or goal-directed activities and considered the realization of the best thing in a person, or one's true potential, as the highest goal and route towards well-being. (Aristotle, 1980). Most of the previous research has been based on hedonic views of well-being, while eudaimonic views of well-being have not received enough attention.

6.3 Measuring well-being

Few studies that studied how unmet needs of out-of-home activities shaped, contributed to well-being, and considered satisfaction in life as the main measure of well-being (Bergstad et al., 2011; Ettema et al., 2010; Nordbakke & Schwanen, 2014). (Bergstad et al., 2011) showed that satisfaction with life was positively influenced by satisfaction with travel directly as well as indirectly through positive feelings associated with participation in out-of-home activities. Moreover, (Hjorthol, 2013) found that satisfaction with mobility is correlated with the mobility level, measured as a number of either trips or activities. A Sweden study studied satisfaction with work commute and how it contributes to overall happiness (Olsson et al., 2013) and there are several more studies which are also focused on work commute happiness.

Mobility in later life is not only about moving from A to B, but also a central to well-being, quality of life, and maintaining independence and social connectedness (Giesel & Köhler, 2015; Pantelaki et al., 2021; Schwanen & Ziegler, 2011). In other words, independence and mobility are important constituents of well-being especially in later life because mobility allows older people to engage in everyday out-of-home activities, stay connected to

communities, friends, and family, and access services. Furthermore, as the number of transportation-disadvantaged older adults increases the number of people who face challenges such as social exclusion, depression, and loneliness has become critical (Adorno et al., 2018), and studies like (Delbosc & Currie, 2011; Jackson et al., 2019; J. Stanley et al., n.d.; J. K. Stanley et al., 2011) examined the connection between social exclusion and well-being.

A Norway study finds that well-being in later life should move beyond silo thinking, therefore, require a cross-sector and holistic approach to policy (Nordbakke & Schwanen, 2014). In this section, we studied the well-being in later life from an equity perspective in Japan's context. Consequently, we consider a number of research questions in the present analysis. First, are older people satisfied with their out-of-home activities, and, if not, which activities are lacking, and why do they refrain from going out? Second, does satisfaction with out-of-home activities and life, freedom to go out, and social isolation can influence well-being in later life? What is the correlation between these measures? Third, how well-being measures differ from an equity perspective and explore if AI on-demand bus can possibly make an impact?

6.4 Older people's unmet travel needs

Individuals participate in different activities in order to fulfil their needs and function in society. Elderly people have more free time to spend on leisure activities, however, (Luiu et al., 2017) found that leisure activities are the ones older people report to be more unfulfilled.

There are three relevant dimensions of well-being are (i) to have, (ii) to love, and (iii) to be, which is first developed by Allardt in 1975 and have been used in transport studies (Hjorthol, 2013; Nordbakke & Schwanen, 2014). To have is the material level of living, trips including shopping trips, service trips, and health services; to love is the non-material aspects of life and more specifically the need for social relations, such as friendship and family ties;

and to be is the need for self-realization and positive judgment of oneself. This study used the one used by (Nordbakke & Schwanen, 2014) that gives a more open and provisional dimension that lists two dimensions for all (details shown in Table 6.1). Six different common activities have been examined in this study. Thus, onsen has been chosen to be one of the prior activities in rural Japan. The onsen culture is, intended as bathing in a group, which emerged from rural society.

We questioned what type of activities older people want to do more if they can move freely and independently by public transportation. Secondly, the questionnaire survey also examined whether elderlies go out when they want to go out or refrain to go out. To understand why older people, tend to not or refrain from going out, we then further look into the underlying reasons and barriers.

Table 6.1 Different type of out-of-home activities

Shopping	to have, as well as to love
Eating out	to be, as well as to love
Exercise	to be, as well as to love
Visiting friends and family	to love, as well as to be
Participation in community activities and events	to be, as well as to love
Going for public bath (onsen)	to be, as well as to love

Satisfaction with out-of-home activities and life

As discussed in the previous chapter, satisfaction with life is one of the main measures to assess well-being. We simply asked their overall satisfaction with life from 5-point Likers scales ranging from “totally dissatisfied” to “totally satisfied”.

(Bergstad et al., 2011) found that satisfaction with the out-of-home activity participation

was directly correlated with subjective well-being. Different out-of-home activities can contribute to the well-being and each individual have their own preferences. Therefore, satisfaction with previously mentioned out-of-home activities was measured with a 5-point Likers scale.

Freedom to go out

Ease and freedom of movement referred to moving freely and effortlessly in all dimensions within one's environment (Rush et al., 1998). In many cases, a car implies freedom and independence for newly retired people (Berg et al., 2015). However, a car is still underused by older people (Luiu et al., 2018), and the freedom to go out has not been used to address well-being in the transport context.

Older people may possibly have several difficulties moving around due to their health situation, unable to drive, mobility choices, and social connectedness, especially during the COVID-19 pandemic. Therefore, we directly asked whether they need help to perform the previously mentioned out-of-home activities freely and independently? Because different activities have their different impact on life, for example, (Hjorthol, 2013) found that shopping for groceries can be characterized as a 'basic' activity and therefore an indicator of independence and control in everyday life. Furthermore, (Lyubomirsky et al., 2005) conclude that varying activities is important for well-being because it prevents them from becoming stale.

Social isolation

As the global population ages, a number of people who face the challenge of social isolation due to insufficient mobility are becoming crucial and the effects on well-being as well as transport equity are substantial.

In this study, we measured social isolation with an index that considers living status, participation in social activities, organizations, events, etc., and frequency of contact with family and friends to move around for daily necessities (Shankar, McMunn, et al., 2011; Steptoe et al., 2013). Scores ranged from 0 to 5, with higher scores indicating greater social isolation. For example, if they lived alone and were not involved in social activities each scored one and one point if they had less than monthly contact with family and friends. This measure gives us more objective perspectives of well-being.

From an equity perspective

(Reardon et al., 2019) analyzed the equity implications of transport on subjective well-being, by reflecting on the nature of demographics that use the different transport modes. (Gordon & Tanton, 2013) measured subjective well-being by looking at transport costs using a case study in Australia however, it did not include other equity aspects besides income. Although it only concerns public health issues, (Chakrabarti et al., 2021) also approached inequalities from a well-being perspective during lockdowns.

In addition to that, it's still no clear further connection between well-being and equity. It is imperative to explore innovative, sustainable transportation options through an equity framework for all older persons regardless of transportation resources and abilities (Adorno et al., 2018).

The main focus of equity is that minimize differences between people. However, those with disabilities, the elderly, children, those on low incomes, and women who tend to rely more on public transportation may also be disproportionally affected in terms of the impacts on their well-being. (Reardon et al., 2019). It's certain that demographics have been found to play an important role in shaping an individual's well-being. Therefore, we compared the well-being of different social groups in order to analyze from a well-being equity perspective.

6.5 Application of Method

6.5.1 Case study

Despite the current situation with the pandemic, Shobara MaaS selected two mountainous areas of Tojo and Taishaku in 2021, and the implementation of the AI on-demand shuttle bus trial has started. AI on-demand bus hasn't fully integrated with the existing buses and other modes. However, these trials would help planners to proceed to fully integrated MaaS. In this research, the data collection was conducted during the trial period and used the obtained trip pattern data from Shobara MaaS. The survey was conducted by the Tojo MaaS council, which consists of Shobara city office, an association of commerce, and some local community groups. To understand the experience with AI on-demand bus, the survey was distributed to people who used the service (n=76).

At the same time, a separate questionnaire survey has been conducted for the people who live in the area of Tojo and Taishaku, using a random sampling approach. The number of respondents was 192 and we considered over 50 years old person as an older person in this study. Table 6.2 shows the descriptive statistics for the respondents. The proportion of male respondents was higher. Most of the respondents (37.6%) were unemployed correlates to the fact that 64.7% of them were above 60 years older. In addition, it was found that more than half of the respondents had a driving license and 82.7% possessed a car and only 5.9% of the respondents don't drive by themselves.

Table 6.2 Socio-economic demographic characteristics of respondents.

Gender %	Age (year) %	Living status %	Profession %	Car ownership %	Driving license %

Male= 73.9 Female= 26.1	50-69 = 20 70-79 = 39 80-89 = 27 Over 90 = 14	Alone = 16.8 With spouse = 44.7 With kids = 19.6 With parents = 8.9 With parents and kids = 10.1	Office / public employee = 16.9 Agriculture / forestry = 23 Self-employed = 9.6 Housewife = 2.2 Part-time = 8.4 Unemployed = 37.6 Others = 2.2	Yes = 82.7 Yes, but I don't drive by myself = 5.9 No=11.4	I have = 85 I don't = 8.9 Had it but returned =6.1

6.5.2 Structural equation modelling

A Structural equation model (SEM) is powerful multiple statistical method that can be used to explore and test the causal relationships between observed variables and latent variables. It has been used widely in different fields, such as sociology and psychology. Recently, many transport studies have been applied SEM to their analysis (Y. Wang et al., 2022).

SEM model consists of a measurement model and structural model. The measurement model describes the relationship between latent variables and observed variables, whereas, the structural model represents the relationship between each latent variable (Byrne, 2016).
The basic equation of the structural model takes the following form:

$$\eta = B\eta + \Gamma\xi + \zeta \qquad (1)$$

in which η: endogenous variable; ξ: exogenous variable; ζ: estimated residual error; β: regression coefficient; Γ: regression coefficient

The basic equation of the measurement model takes the following form:

$$y = \Lambda y\eta + \varepsilon \qquad (2)$$

$$x = \Lambda x\xi + \delta \qquad (3)$$

y: observed variable; x: observed variable; Λ_y: factorial load; Λ_x: factorial load; ε: error; and δ: error.

Initially, measurement models are developed and correlations between observed and latent variables are confirmed. Then the measurement models were combined to develop the structural model (Ashraf Javid et al., 2021). A structural model is a path diagram that elaborates the measurement and structural equations. We then simultaneously analyzed the relationships between satisfaction with life, satisfaction with out-of-home activities, freedom to go out, and social isolation.

6.6 Findings from older people's travel needs

If older people can go out relatively freely by public transportation when they want to go out, what kind of activities would they want to increase? Older people's travel needs might be deferred from other people. It's also important for planners, transport operators to know that type of activities that people would like to increase in their later life. Table 6.3 gives information about the types of activities that women and men and different age groups would like to increase if they were able to go out when they want to go out by public transport. Shopping has the highest percentage out of all activities with 51% followed by eating out and visiting friends and family both having (16%). The desire for more frequent shopping activities increases with age however, less people almost none wanted to increase activity of exercise for over 80 years old. In most cases, women want to do the following activities more than men do even though one-third of respondents were women. This possibly indicates that the transport resources available to them are fewer than for men.

Table 6.3 Activities that older people want to do more often

Activities	**Percentages**						
	50-69	70-79	80-89	Over 90	Woman	Man	All
Shopping	37	56	68	73	68	32	51

Eating out	18	22	5	18	58	42	16
Exercise	18	2	0	0	75	25	4
Visiting friends/family	24	13	21	9	63	37	16
Going for public bath (onsen)	3	7	5	0	40	60	4
Others							9

When implementing new mobility systems like MaaS, it is crucial to identify the facilitators and barriers to older people's mobility; before clarifying how MaaS can be developed for the elderly. This research examined if older people move around when they want to without barriers or if so, what are the reasons behind why they tend not to go out. Table 6.4 shows that one-third of respondents refrain to go out because of different underlying reasons and barriers. Most respondents said that the main reasons why they refrain to go out are community sharing taxi fare is high 23% even though the operation of community sharing taxi is subsidized by the city and the fares are relatively cheaper than the regular taxi. They also stated that there is no regular bus service at the time they want to use (23%). This explains that the frequency of public transportation is not enough for older people and the public transportation network isn't also enough to cover the vast area of Shobara. Furthermore, carrying luggage and shopping bags was a burden for older people (18%) especially when they go shopping by public transportation. Only 3% of the respondents said the bus fare is high. It indicates that the affordability of public transportation is not a significant barrier for older people.

Table 6.4 Understanding the barriers

I can go out when I want to go out	62%
I want to go out, but I refrain to go out	35%

↓ The reason why they refrain to go out		
There is no bus service at the time I want to use	23%	
Regular bus fare is high	3%	
Community sharing taxi fare is high	23%	
Far away from bus stop	8%	
It's difficult to carry luggage/shopping bag etc.	18%	
I have a place I want to go but there is no means of transportation	15%	
I am worried about the burden on those whom I dependent on (family, friends etc.)	5%	
Others	8%	
I don't want to go out that much		3%

6.7 Results of Structural Equation Modeling

SEM generated through AMOS was used to test the relationships. A good fitting model was accepted if the value of the CMIN/df and goodness-of-fit (GFI) indices was < 3.00 (Hair et al., 2010). In addition, an adequate-fitting model was accepted if the AMOS computed value of the standardized root mean square residual (RMR) was < 0.05, and the root mean square error approximation (RMSEA) was between 0.05 and 0.08 (Hair et al., 2010).

The fit indices for the model shown in Table 6.5 fell within the acceptable range of CMIN = 109.69, GFI = 0.92, and RMSEA = 0.07. Therefore, the results show that the model's degree of fit is appropriate, and the measurement model is proven valid, reliable, and fit for further analysis.

Table 6.5 Model fit indices

Model fit indices	CMIN	CMIN/DF	GFI	SRMR	RMSEA
Model-based value	109.69		0.924		
Standards	--	1<CMIN/df<3	>0.95	<0.08	<0.06
Status		Excellent	Acceptable		Acceptable

Table 6.6 shows the estimation results of the path coefficients in the structural model. The path coefficient represents direct effects between the latent variables. This research calculated satisfaction with life as a well-being and assumed that freedom to go out has a positive and direct effect on satisfaction with life (H1), satisfaction with out-of-home activities (H2), and social isolation (H3). Satisfaction with out-of-home activities has the greatest positive effect on well-being (path coefficient 0.52; p<.01). For different out-of-home activities, the largest effect comes from meeting up with family/friends on the satisfaction with out-of-home activities (0.92; p<.01), followed by activity of exercise (0.91). Freedom to go out has a positive effect on well-being (0.02; p<.01) which related to mobility of older people. From this estimation, we can say that mobility for older people has impact on their well-being.

Table 6.6 Standardized path coefficient and t-value for the structural model.

	Estimate	**S.E**	**p-value**
Freedom to go out -> satisfaction with life	.34		
- Shopping-> Freedom to go out	.74	-	
- Eating-out->Freedom to go out	.80	.072	***
- Exercise-> Freedom to go out	.90	.087	***
- Meeting-up-> Freedom to go out	.93	.086	***
- Participating activities-> Freedom to go out	.94	.087	***
Satisfaction with out-of-home activities -> satisfaction with life	.52		
- Shopping-> Satisfaction with out-of-home activities	.86	-	
- Eating-out-> Satisfaction with out-of-home activities	.89	.094	***
- Exercise-> Satisfaction with out-of-home activities	.91	.088	***
- Meeting-up-> Satisfaction with out-of-home activities	.92	0.102	***
- Participating activities-> Satisfaction with out-of-home activities	.84	0.1	***
Not socially isolated -> satisfaction with life	-.03		
- Family structure-> Social isolation	1.14	.48	-
- Participating activities-> Social isolation	.00	.48	.29
- Need a family/friends help-> Social isolation	-		.951
Satisfaction with life			

The overall impact of variables on well-being is illustrated in the structural model (Figure 6.1) and a summary of variables with its symbol and description is shown in Table 6.7. The

result of the structural model with standardized positive effects except social isolation. This may explain that social isolation measurements were not suitable for Shobara's case. Moreover, rural communities are often small, and everybody tend to know each other thus, it seems older people doesn't have the attitude of participating in social activities, organizations, events, etc.

Table 6.7 Summary of variables

Variable	Symbol	Description
Social (Social isolation)	SI1.1	Contact with family and friends to move around for daily necessities.
	SI1.2	Participation of social activities, organizations, events, etc
	FAM_ST	Living structure
Freedom (Freedom to go out: Need help to perform activities freely and independently)	FR1.1	Shopping
	FR1.2	Eating out
	FR1.3	Exercise
	FR1.4	Visiting friends and family
	FR1.5	Participation in community activities and events
Satisfaction (Satisfaction with out of home activities)	SF1.1	Shopping
	SF1.2	Eating out
	SF1.3	Exercise
	SF1.4	Visiting friends and family
	SF1.5	Participation in community activities and events
Life (Satisfaction with life)	SL1.1	Satisfaction with life

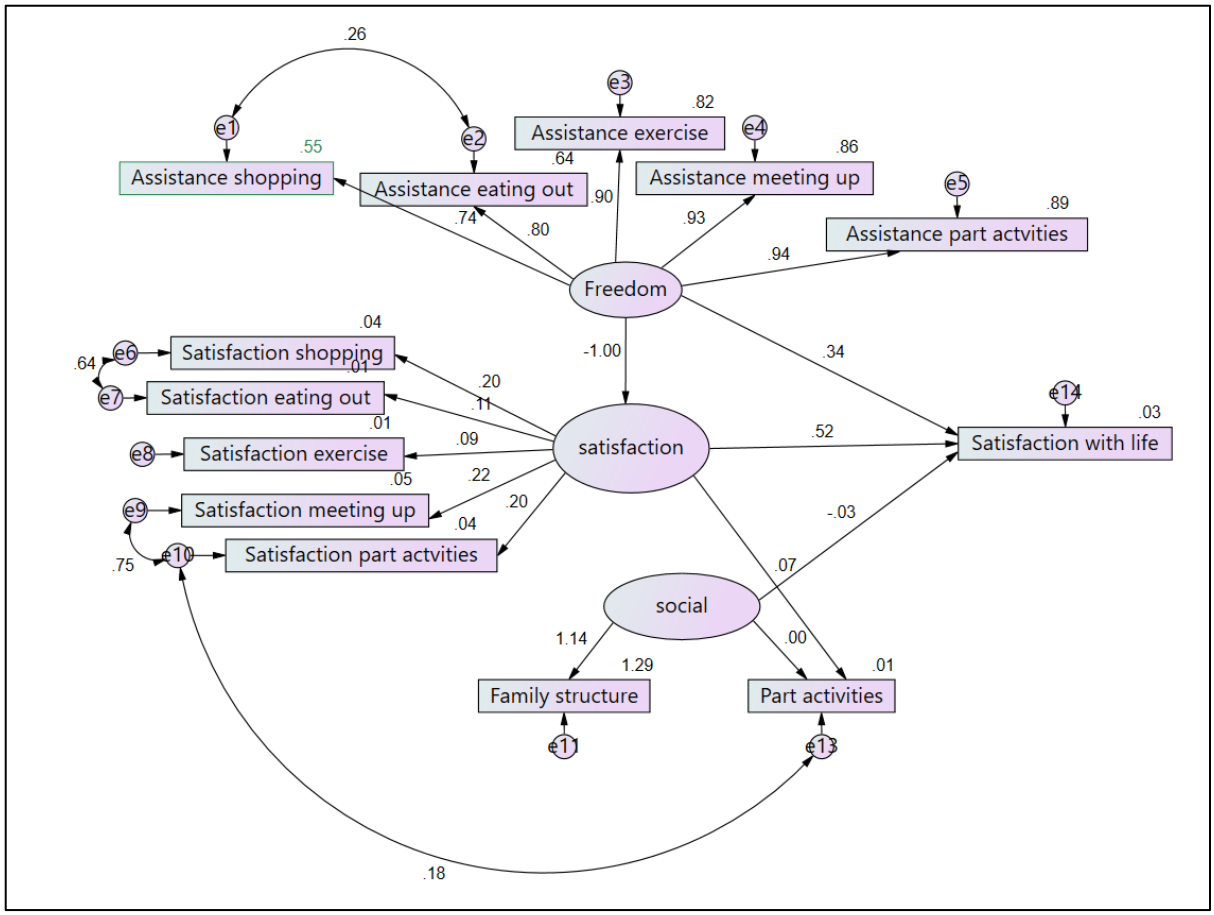


Figure 6.1 The result of the well-being model

**significant 5%, ** significant 1%*

6.8 Inequal well-being of different groups of people

The four well-being measures have been compared with different demographics. This way the effects of transport on well-being could be captured for all socio-groups. Table 6.9 summarized the four measures of well-being and satisfaction measured with the 5 Likert scales however, we modified it to three out-of-home activities that were chosen to be the activities that older people would like to do more.

Age: The result shows that most respondents were not satisfied with the activity of visiting friends/family (22%) than the other out-of-home activities. Particularly the oldest (90+) in the group wasn't satisfied at all (0%) indicating that the older you get more you have not fulfilled the activities of meeting with your friends and family. At the same time, their level of social

isolation was significantly high (90%) having a huge difference from the 50-69 years old age group people (53%). A similar result is shown in terms of freedom to going out, more than half of the oldest (90+ years) answered that they need help from someone to perform all the activities specifically shopping having the highest (89%) – this shows an ability to handle everyday life is not well and they are most in need to perform daily activities. Overall satisfaction with life didn't show a significant difference between population groups however, those who were satisfied with their life were often younger than 90+ years old.

Gender: The difference in freedom to go out was significant between women and men. Almost half of the women answered that they need help to go shopping (44%) than men (10%), and a similar pattern was observed for eating out. This result supports our previous outcome that transport resources are more available to men than women. On the other hand, women had a higher overall satisfaction level than men, but their social isolation level was high (84%).

Living status: Living status have not had huge differences nonetheless, people who live alone had drastically higher social isolation level (87%). None of the people who live alone was satisfied with the activity of eating out.

Car ownership: Overall satisfaction level was lower for the people who have a private car yet don't drive by themselves. Freedom to go out had a great difference between the people who have access to a car and not. Shopping was the highest activity that needed help to perform for the people who don't have a private car (91%) and who can't drive a car (78%). People who have access to the car also needed help and most of them were over 70 years old. More than 90% of the people who don't have access to a car had high social isolation levels.

6.9 Usage of Shobara MaaS and Other Transport Modes

The usage of AI on-demand bus was low (8.7%). The result showed that respondents answered that their out-of-home activities are likely to increase (56%) with AI on-demand bus

(Figure 6.2). During the implementation of MaaS, 35% of the respondents say that the number of going out slightly increased or significantly increased, has no impact on out-of-home activities are 46% (Figure 6.3).

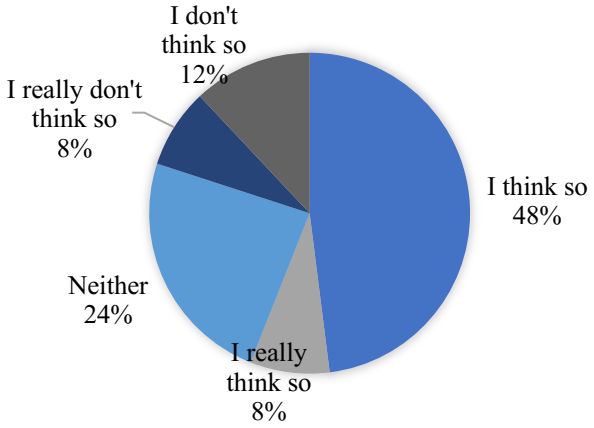


Figure 6.3 The number of out-of-home activities likely to increase.

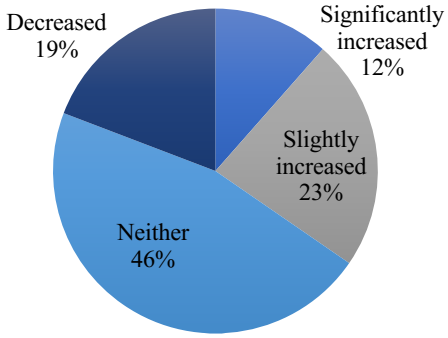


Figure 6.2 The number of out-of-home activities during the experiment

Furthermore, we asked the users impression from the real experience of riding AI on-demand (Figure 6.4). AI on-demand bus stops are planned to fill the gaps that traditional bus cannot serve therefore, almost 80% of the users agreed that new bus stops were close to their home and made it easy to get on. Additionally, 59% of the users agreed that bus stops were convenient for them to carry heavy shopping bags since the bus stops are often placed next to commercial facilities such as shops, restaurants, and cafes. More than half of the users thought that the schedule is suitable however, 50% of the older adults answered that they found it troublesome or difficult to make reservation. Unlimited passes seem to not have an impact on user's number of out-of-home activities on the other hand, implementing bonus point for each AI on-demand bus ride would possibly increase people's usage.

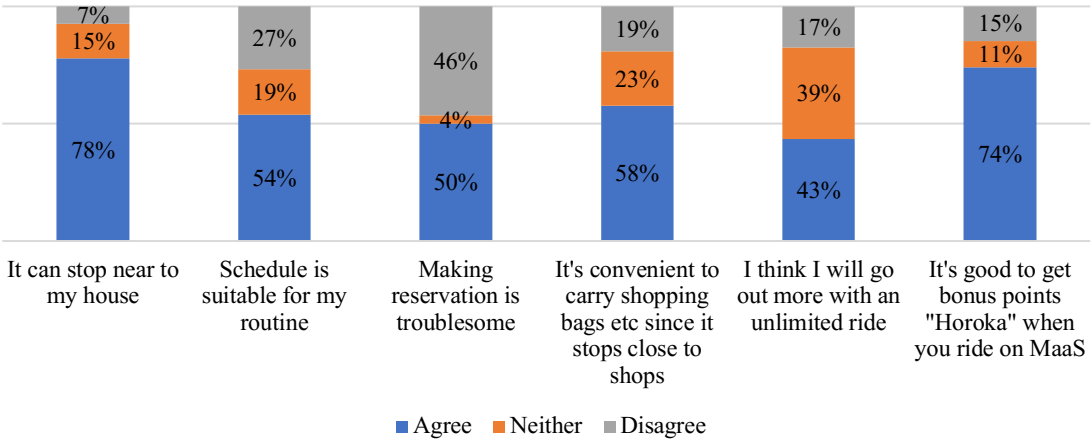


Figure 6.4 User's response on using AI on-demand bus

The usage of public transportation is significantly low in rural areas of Japan. Our result (Figure 6.5) shows that 67% of the respondents rarely used the bus in their daily activities. They don't use it because bus service is not operating in the area (21%) which indicates that buses are not enough to cover the area. At the same time, the community sharing taxi usage was also drastically low and 84% of them rarely used a community sharing taxi (Figure 6.6). In short, bus and taxi usage in Shobara was extremely low and most of the respondents didn't use it about once a week or month.

Lastly, we tried to understand the reason why the regular bus and community sharing taxi usage was low for older people (Table 6.8). Car dependence was incredibly high in Shobara, 84% of them answered that it's because they have a private car. The result shows that making a reservation for community sharing taxi is difficult for older people (13.6%) even though they simply need to give a call to community organization office, not a taxi company. Regular bus and community sharing taxi cannot be used at the time you want which shows that frequency of public transportation might be low. Community sharing taxi is only available at daytime on the weekdays meanwhile regular taxis are available anytime.

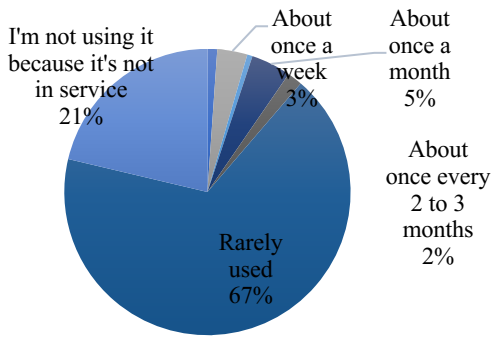


Figure 6.6 Bus usage

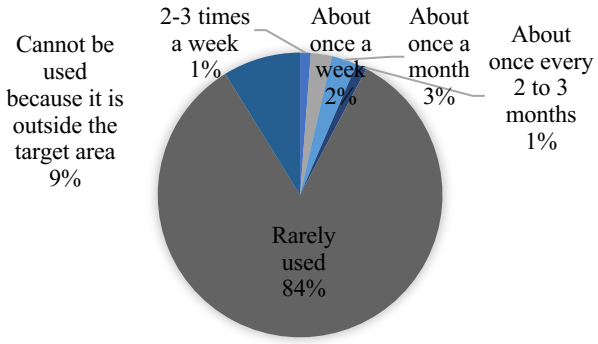


Figure 6.5 Community sharing taxi usage

Table 6.8 The reason why people rarely used regular bus and community sharing taxi

No need to use because I have a private car	84.3%
I can't drive by myself, but my family pick me up	11.4%
The fare is high	6.4%
Regular bus and community sharing taxi cannot be used at the time you want	12.9%
Community sharing taxi is not available on the day you want to take	10.0%
Reservation is difficult to make for community sharing taxi	13.6%
The bus stop is far away	7.9%
I don't know much about local buses and taxis	10.0%
There is no particular reason	6.4%
Other ()	3.6%

Table 6.9 Differences in socio-groups

		Age				Sex		Living status			Car ownership			All
		50-69	70-79	80-89	90+	Woman	Man	Alone	With spouse	3+	Yes, I do drive	Yes, but I don't drive	No	
Satisfaction with different activities	**Shopping**													
	Neither	43	31	37	75	31	39	39	44	31	36	30	47	37
	Satisfied	45	57	51	25	62	46	50	38	59	51	60	35	51
	Dissatisfied	12	12	12	0	7	15	11	18	10	13	10	18	12
	Eating out													
	Neither	52	56	56	63	53	54	88	49	49	55	33	75	56
	Satisfied	26	26	27	24	39	24	0	29	34	27	44	13	27
	Dissatisfied	23	18	18	13	8	22	22	22	16	18	23	12	18
	Visiting friends/family													
	Neither	51	48	37	86	33	50	37	55	46	50	62	27	13
	Satisfied	36	39	51	0	48	37	48	30	41	41	13	40	65
	Dissatisfied	13	13	12	14	19	13	15	15	13	9	25	33	22
Satisfaction with life														
	Neither	45	44	43	67	44	52	48	46	41	33	71	20	43
	Satisfied	40	41	41	16	41	27	33	35	38	31	14	47	41
	Dissatisfied	15	15	15	17	15	21	19	19	11	10	15	33	15
Freedom to go out	**Shopping**													
	Required	8	10	4	89	30	5	29	16	18	8	78	64	71
	Occasionaly required	4	13	16	11	14	5	18	12	6	10	0	27	18
	Not required	88	77	80	0	56	90	54	72	76	82	22	9	11
	Eating out													
	Required	4	10	16	57	20	1	16	7	17	5	38	59	76
	Occasionaly required	17	10	6	29	12	6	8	17	9	13	12	6	12
	Not required	79	80	77	14	68	93	76	76	74	82	50	35	12
	Visiting friends/family													
	Required	8	11	21	63	21	12	15	10	15	7	44	45	74
	Occasionaly required	4	10	24	25	17	12	10	12	10	12	11	20	13
	Not required	88	79	55	12	62	76	75	78	75	80	45	35	13
	Social isolation													
	High	53	63	72	90	84	60	87	60	62	58	92	96	64
	Low	47	27	28	10	16	40	13	40	38	42	8	4	36

6.9 Summary

Findings from SEM analysis give evidence that satisfaction with out-of-home activities has the most significant effect on satisfaction with life. Freedom to go out also has a significant effect on satisfaction with life, implying that mobility has a direct impact on satisfaction with life in other means of well-being. However, social isolation has no significant impact on satisfaction with life so a few conclusions can be drawn there. Whether older people in Shobara depend on their family and friends for daily necessities did not impact how much they are socially excluded. However, participation in social activities, organizations, and events showed a significant correlation with social isolation, suggesting that older people feel more socially included if they are part of a community or group. Shobara is a small city; therefore, if we increase participation in social activities, organizations, and events, it could result in reduced social isolation among older people. Overall, the SEM analysis explains that the three measures of social isolation are insignificant in Shobara's case. Nevertheless, well-being can be measured in terms of freedom to go out and satisfaction with life and activity. The rest of the results are from explanatory analysis.

Shopping was the activity that most people wanted to do most often regardless of age, followed by visiting friends and family and eating out, with the same value of 16%. However, results showed a notable difference by sex group. In most cases, women wanted to do more activities than men, especially shopping, exercising, and visiting friends and family. Furthermore, few respondents wanted to increase the activity of going to the hospital, indicating that health is essential for older people.

Those over 80 or 90 years old had high social isolation levels and were not as satisfied with their out-of-home activities as the other age groups. Similarly, they needed help to go out, showing that fulfilling daily activities was challenging for their age bracket. In addition, those respondents who had access to a car had significantly higher freedom to go out than those who

did not, which also related to lower satisfaction and social isolation levels. When examined through an equity lens, with well-being linked to socioeconomic status, the results demonstrate that measures of well-being are correlated and lower for individuals without car access and older age groups.

The study further examined the barriers to accessing transportation in order to participate in everyday life. Likewise, the questionnaire explored why the usage of regular buses and community-sharing taxis was low and whether older people think that their out-of-home activities were likely to increase with AI on-demand buses. Analysis of these reasons and barriers concluded that public transportation is not enough, and going shopping with public transportation is not convenient for older people. The planning of AI on-demand bus stops was suitable for most users, as much as older people, to do shopping, given their proximity to commercial places. More than half of the users deemed the schedule suitable, but 50% of the older adults found it troublesome or difficult to make reservations. This result suggests that older people are not familiar with new MaaS services. Based on users' opinions, offering bonus points seemed more impactful in increasing people's usage of AI on-demand buses instead of an unlimited pass.

However, this research has some limitations in terms of a limited sample size. Although there were concerns that individuals may lie or be unreliable about their level of well-being, this study alleviated these possibilities by conducting an anonymous survey. Furthermore, well-being modeling did not include the frequency of AI on-demand buses because the main questionnaire for the citizens did not cover it.

CHAPTER 7

Development and implementation of equity in Japan

7.1 Introduction

One of the challenges to MaaS's success is the collaboration between stakeholders and the need for a shared vision and legislation of governance systems (Audouin & Finger, 2018; Karlsson et al., 2020; Polydoropoulou et al., 2020). MaaS's vision should be firm yet adaptable and developed in collaboration with many important stakeholders (Smith et al., 2018). However, it is stated that there is no consensus reached on the initiative of cooperation between stakeholders in regional public transport or among different stakeholders in Japan (Smart Mobility Challenge, 2021). Implementing MaaS requires a wide variety of organizations and stakeholders, which makes it challenging to coordinate on-site. Moreover, there is a lack in the local government's understanding and recognition of local transportation issues within the community, as well as their dismissal of digital technology, leading to a lack of interest in the mentioned issues and the proposal or seeking of solutions in the planning phase. The crucial questions we need to ask are who oversees MaaS, and who should be its facilitator.

The everyday experiences, perceptions, and needs of the poor, notably slum residents, and of broader vulnerable groups are often not only marginalized but stigmatized (particularly through the association of low-income areas with criminality), both by the government and private sector planning partners (Pereira and Boisjoly, 2021). Certainly, both the public and private sectors often overlook social equitable goals. That said, the subject of equity analysis has been getting more attention in the transportation sector for the past few decades. Policymakers and government institutions began to devote considerable resources to supporting and maintaining an extensive multi-model transportation network (Susan Shaheen & Adam Cohen, 2017). However, the definition and concept of transportation equity in Japan

is not well discussed and defined at both government and private industry levels. Identifying equity issues in Japan's context is an essential first step for developing equity indicators.

One of the expectations from implementing MaaS is how it could transform and confront some social issues. (Butler et al., 2021) stated that MaaS's implementation is expected to have improved social equity and mentioned its potential to offer disadvantaged groups greater freedom to satisfy their mobility needs. New innovative mobility solutions are emerging at a fast pace as technologies evolve. However, there is an inevitable mismatch between existing policies and the operation of MaaS services and an unwillingness to apply new solutions. Therefore, it is important to address equity issues early in MaaS developments between operators, stakeholders, and facilitators.

7.2 The role of institutional and governance organizations

Redefining the role of the institutional and government organizations and all the other stakeholders is crucial for successful future MaaS implementations. Cooperation with existing transport companies and local governments is vital in implementing the appropriate business model in the respective regions (The World Economic Forum, 2020). Moreover, government intervention is required to harness the societal impacts of new mobility systems and help providers tackle wicked mobility problems. Public authorities should explore network-based and experimental approaches to public innovation to facilitate partnerships with the private and civil sectors that advance the development and diffusion of MaaS (Smith & Hensher, 2020).

Local administrative institutes in Japan have two levels:

1. Municipalities* (Shi-Cho-Son)
2. Prefectures* (To-Do-Fu-Ken)

Municipalities do not have the authority over local transportation because all fundamental authority goes to the central government, and prefectures support small municipalities. Small municipalities find it difficult to play a role in mobility issues and policy implementation;

therefore, they must be supported by the central government or other local governments. However, municipalities are required to play a subjective role in local mobility policy under the new transportation laws legislated by the Japanese government (Act on Revitalization and Rehabilitation of Local Public Transportation Systems, 2007, revised in 2014 and 2020 and the Basic Act on Transportation Policy, 2013) (The World Economic Forum, 2020). These changes have been occurring since the 2000s. Two significant characteristics of such changes are 1) the legal positioning of local governments has become clear-cut and important, and 2) the linkage between transportation policies and community development policies is called for in terms of legal systems as well (Kimura, 2016).

The Basic Act on Transport Policy has three basic functions:

1. Realize user-friendly transport that contributes to the rich lives of the citizens
2. Build up the interregional/international passenger transport and logistics networks that create a foundation for growth and prosperity
3. Create a foundation of sustainable, secure, and safe transport

One of the measures on transport from the Basic Act on Transport Policy (Law No. 92 of Dec. 4, 2013) states that the government shall implement and establish policies on transportation comprehensively and systematically (Act No. 92, 2013, MLIT). Furthermore, it mentions the reconstruction of the regional transport networks under local governments' initiatives, in coordination with town planning policies. This policy implies the importance of coordination with relevant measures to create active and unique communities, considering population decrease, super-aging, and reliance on automobiles to vitalize local public transport services (Act No. 92, 2013, MLIT).

Table 7.1 Institutional and governance organizations

	Central government	Local government
Authority and role	• Set appropriate laws, rules, regulations, and fiscal arrangements • Defining standards, appropriate regulatory frameworks • Must establish a basic plan for transportation policies • Takes legislative, financial, and other measures that are necessary to implement policies on transportation • Organizes seminars and symposia to transfer knowledge	• Municipalities are required to play a subjective role in local mobility policy • Responsible for formulating and implementing policies on transportation following the natural and socioeconomic characteristics of their domain • Maebashi city develops a community council and a facilitator while transport operators oversee the system provider
Scale	• Supports local government with basic resources • Takes necessary measures to promote mutual coordination and cooperation between relevant parties, such as promoting conferences between the state, local governments • Subsidizes the transportation budget	• Large municipalities can establish a special department for each policy or technical matter • Small-sized municipalities have only a small capacity and limited knowledge of technology and resources • Prefectures have more detailed information about the regional mobility situation

Data sharing	• The central government has been promoting open data in the field of public transportation • Open data have the potential to revolutionize the public transportation sector widely, including creating new services that improve user convenience and benefits for the business operations of transport operators • The operator manages the data, and the data usage is shared with the city	

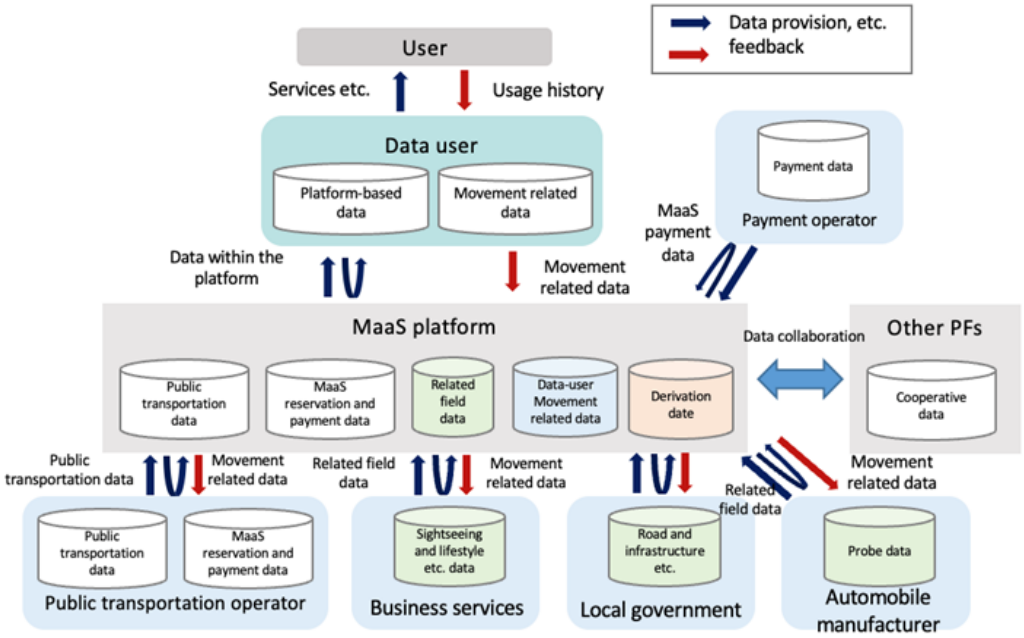


Figure 7.1 Data Integration in MaaS

Funding	• Subsidizes the MaaS projects • Continuous funding is required to keep the business on track	• Received subsidies from the central government and managed the public finance • Needs to downsize the city's budget when the subsidy runs out of budget, which often happens
Current problem	• Standards are strict • Procedures are complicated • There is no flexibility • Small-sized municipalities cannot receive support from the central government	• It is difficult for local governments in small and medium cities to know about technology, etc. • Do not have enough financial resources to support public transportation • Challenging to carry over if the large project takes several years to complete

7.3 Case studies

The methodology used in this paper is fundamentally qualitative. We first used data from gray literature, such as reports, white papers, and press releases. We also interviewed the head of each MaaS project to obtain the information we could not find on the Internet (Table 7.2).

This paper mentioned how the central and local governments play an important role in implementing new mobility options and how Japan is unique in terms of its institutional organizational structure in the previous section. We analyzed two leading MaaS projects that can be considered successful and were operated since MaaS began implementation in Japan. MaaS projects were selected as the 52-target region under the "Smart Mobility Challenge project" in 2020.

Table 7.2 Conducted interviews.

	MaeMaaS	**Shizuoka MaaS**
Project head	Government development Maebashi city office is the main player	Private industry development Private Shizuoka railway
Interviewee	Manager Akio Ohmae at Next Generation Transportation Promotion Section of Shizuoka City Hall Transportation Policy Division	Director Daiki Irisawa at the Regional Traffic Promotion Office of Maebashi City Future Creation Deparatment Transportation Policy Division
Interview type	2022.09.21 (virtual)	2022.09.15 (face-to-face)

The project head for MaeMaaS is the local government, and they also comprise participating organizations and members of the council, including several different private and public organizations. Therefore, we interviewed Director Daiki Irisawa at the Regional Traffic Promotion Office of Maebashi City Future Creation Department Transportation Policy Division regarding information we could not find online. Table 2 shows the authority, role, and

scale difference between the central and local governments. It is important to describe their role in realizing the benefits MaaS brings.

7.3.1 MaeMaaS, Maebashi

Maebashi is the capital city of Gunma prefecture, located in Kanto, central Japan. The total estimated population was 335,352 in 2020. Maebashi introduced MaeMaaS with the support of the METI and the MLIT to maintain the local transport and restructure the city's transport network. MaeMaaS aims to improve transport convenience by integrating public transportation with shopping, enabling searchability, booking, and payment of all public transport routes, and increasing the attractiveness of visiting the central city area (MLIT, 2022). The number of registered members reached 2,500 by March 2022 since its operation in September 2021.

Current transport issues include the following:

- Increase in financial burden on municipalities to maintain public transport
- Increase in traffic accidents caused by elderly drivers
- Accessibility to the city center from the suburbs is poor
- Opportunities to travel are limited in areas with no public transportation

Maebashi and Shin-Maebashi stations have a high concentration of users, while Chuo-Maebashi and Ogo stations see limited use. A bus network from the city center to the suburbs has been formed. However, the frequency of each line operation is low, and there is concern that it does not function well as an interregional network. Community buses (Mybus) operate around Maebashi and Shin-Maebashi stations to circulate in the city center. On-demand bus services (Runrun Bus, Furusato Bus, and Jonan Aozora-go) that operate in three different city areas are also available on the MaeMaaS app. Below are the areas in which they operate.

- Runrun Bus (Fujimi area)
- Furusato Bus (Ogo, Miyagi, Kasukawa area)
- Jonan Aozora-go Train (Jonan area)

- MaeMaaS services include the following:
- Implementation of various simulations and fare pool distribution for joint management of bus routes
- Provision of real-time route search using open data
- Route search (bus locator, shared bicycle, on-demand transportation, etc.)
- Sales of digital free passes
- Provision of discounts for Maebashi citizens based on citizen authentication card (my number card)
- Provision of a search function for local tourist facilities and restaurants
- Benefits at shops for purchasers of digital free passes for local buses

Maebashi city operates MaeMaaS. As such, we interviewed the Maebashi city officials to explore equity impacts and their role, authority, regulation, and funding in operating MaeMaas.

Table 7.3 Institutional organization structure of MaeMaaS

Project head	**Maebashi City – Maebashi City New Mobility Service Promotion Council**
Participating organizations	NTT DATA Corporation, Jomo Electric Railway Company, Gunma Bus Association, Maebashi Area Taxi Council, East Japan Railway Company, ICT Community Development Common Platform Promotion Organisation, Mirai Share Co.

7.3.2 Shizuoka MaaS

Shizuoka is the capital city of Shizuoka Prefecture, a city on the south coast of Japan with an estimated population of 698,275 in 2020. Shizuoka MaaS is a community-based public-private consortium and launched in May 2019 to provide new mobility services that are accessible to all, incorporating the latest technologies, such as ICT and AI, to create a sustainable town amid a declining population and an aging society. Shizuoka MaaS operating areas include the Tamagawa area, Shizuoka City in Shizuoka Prefecture (a mostly hilly and mountainous area), and areas along the Shizutetsu train lines. An AI on demand bus system is

implemented, where the MaaS service links different transportation modes such as trains, buses, and taxis. People who signed up for the MaaS service reached 456 in two months of the demonstration project in 2020.

Current transport issues include the following:

- Car dependence is high; there is an increase in travel needs that do not rely on private cars
- Traffic accidents caused by elderly drivers are increasing
- The population and birth-rate are declining, and the current population is aging
- Maintaining a fixed-route bus is currently financially sustainable

Shizuoka MaaS services include the following:

- Linkage between different modes of transport such as railways, buses, and taxis
- Route search for railway and buses
- Free demonstration of AI on-demand transport operation with the participation of residents
- Functionality that allows the booking of AI on-demand transport easily
- Creation of livelihood support services (e.g., remote shopping support using smart glasses)
- Content for travelers (e.g., local events such as veranda cafés) and linkage with transport services
- Coupon distribution according to railway usage times and personal characteristics

One of Japan's main transport operators, JR West, is the project head for Shizuoka MaaS. Several other organizations are not only from the private sector but also Shizuoka City and other governmental organizations.

Table 7.4 Institutional organization structure of Shizuoka MaaS

Project head	**JR West**

Participating organizations	Shizuoka City, Shizuoka Taxi Association, Edashima City Tourism Association, Shizuoka City Council of Social Welfare, Suruga Planning and Tourism Bureau, Shizuoka Bank, Ltd.
Observers	Shizuoka Transport Branch Office, Chubu Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Shizuoka National Highway Office, Chubu Regional Development Bureau

7.4 Measuring equity with equity indicators

One of the most used practical applications of measuring equity is the distribution of accessibility among different population groups. Accessibility measures can be used as a social indicator if they show the availability of social and economic opportunities for individuals (or groups of individuals), i.e., the level of access to essential sources for human existence, such as jobs, food, health, and social services, along with the potential for social interaction with family and friends (Geurs & van Wee, 2004). Similarly, social inclusion is another critical topic when we discuss equity issues in transportation. (Manaugh et al., 2015) suggest that the application of social equity indicators should specify the impacts and improve the inclusion of disadvantaged groups. When catalyzing and establishing a MaaS ecosystem, the ecosystem should be open to all service providers and inclusive for all users, including persons with reduced mobility or disabilities (MaaS alliance, 2017). Lastly, studies look at affordability, which refers to transportation cost, ensuring everybody can afford basic mobility. Van Dort et al. (2019) concluded that more research is necessary to identify how new mobility options can be made more accessible for low-income communities. In summary, accessibility, inclusivity, and affordability overlap; without considering inclusivity, we cannot reach accessibility, and affordable mobility means inclusive and accessible mobility for low-income people (Figure 7.2).

Achieving equity requires a discrete competency and knowledge base that agency leadership should prioritize and cultivate (Transit Center, CNT, 2021), as well as various indicators. (T. A. Litman, 2021) stated several equity indicators to achieve equity objectives,

including fair share, external costs, inclusivity, affordability, and social justice, under vertical and horizontal equity. Van Dort et al. (2019) proposed indicators for advancing transportation equity within and beyond the transportation sector and engaged multiple stakeholder groups, including a project advisory group with experts in addressing disparities and inequities, a group of transportation users and equity stakeholders, and community members. An equity strategy should outline how to prioritize the needs of people who have been marginalized from the transportation system (Transit Center, CNT, 2021). This study used six equity indicators to measure the equity evidence of the two MaaS projects we have chosen. Questionnaires were prepared separately for each case, and heads of the projects were interviewed regarding equity concerns.

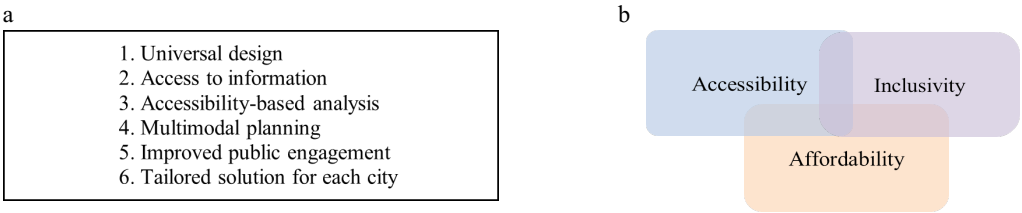


Figure 7.2 (a) Equity indicators; (b) Equity objectives

Universal design

The universal design stands for planning accessible to a wide range of people, regardless of age, gender, race, disability, or status. The objective of universal design is an environment where the transport system accommodates people with disabilities and other special needs (T. A. Litman, 2021). Universal design or accessibility is a feature of many transport legislations, with government and transport providers often obliged to make public transport available to most groups of passengers (Aarhaug & Elvebakk, 2015). Therefore, we studied whether two selected MaaS projects adopted universal design standards for all transport facilities and services.

In 2006, a new “barrier-free” law was enacted, and extensive maintenance was created for people with disabilities, including traffic curbs, step-free train or bus stations, guide blocks,

accessible toilets and chairs for wheelchair users on high-speed trains (shinkansen), and parking for people with disabilities. However, barrier-free design solely focuses on providing access to individuals with disabilities.

Access to information

Having access to digital elements and information about transport in urban settings is crucial for older people. Therefore, (Aarhaug & Elvebakk, 2015) developed a framework to study age-friendly smart mobility. (Casadó et al., 2020) addressed issues of digital inclusion in the most deprived areas of the city and stated the difference between adults' and young people's problems with information complexity associated with new mobility services. Furthermore, they discussed identifying specific considerations and barriers to young people's perceptions of MaaS. Moreover, (Casadó et al., 2020) explained how older residents are less likely to be early adopters of integrated mobility platforms. MaaS provides real-time information and integrates a variety of transport modes into a single application or online interface. Hence, it is important to address barriers to access related to difficulties in getting information, especially for underserved communities.

Accessibility-based analysis

Accessibility emerges as a central indicator for measuring equity in several studies. Lucas (2012) defines equity as the absence of systematic differences in accessibility values between different groups. Lucas and Currie (2012) argue that social exclusion emerges from inaccessibility to jobs, education, social, and cultural opportunities available at specific destinations (i.e., locations in the city). Jittrapirom et al. (2017, 2018) point out that MaaS could positively address accessibility and equity because of a shift from vehicle ownership to mobility access. Therefore, prioritizing accessibility level in MaaS planning is essential,

especially for larger vulnerable groups (women, children, older people, and people with disabilities).

Multimodal planning

Multimodal planning considers various modes (walking, cycling, automobile, public transit, and so forth) and connections among modes (Todd Litman, 2021). MaaS can be considered the next step in integrated transport or multimodal mobility (Todd Litman, 2021). It also allows multimodal trip planning, booking, and reservation (e.g., public transport ticketing, reserving a rental car), en-route support, in-trip alteration, and payment (Jittrapirom et al., 2018). Single-mode users, especially car drivers, are less likely to be multimodal than those who use or depend on public transport. Multimodal planning favors affordable and resource-efficient modes, least-cost funding, pricing reforms (Todd Litman, 2022).

Improved public engagement

Mobility is positively correlated with the likelihood of social inclusion: higher trip-making implies less risk of social exclusion (ITF, 2021). Participation in social activities, organizations, events, and so on, and frequency of contact with family and friends to move around for daily necessities have been used in studies to measure social inclusion (J. Stanley et al., 2011). Particularly for senior citizens, public transport will have an increasingly important role in ensuring independent living and social inclusion of large parts of society (Shankar, Mcmunn, et al., 2011; Steptoe et al., 2013). Therefore, newly implemented mobility options should also take part in improving public engagement to reach opportunities (i.e., facilities, services, activities, or interactions) that enable them to participate in the economic, political, and social life of the community.

Tailored solution for each city archetype

MaaS projects in Japan have specific goals and targets. The key is to create and provide transport services and destinations that make it easy for residents to travel and to increase the demand for available transport through tailored programs that motivate people to travel within the local area (Fiedler & Consult, 2007). Adopting appropriate business models tailored to that region and vulnerable groups is important.

7.5 Findings

MaaS trend and implication have a specific target they intended to be led by the local government and private industries. Thus, we aim to address the equity implications of two different MaaS cases developed and implemented by both government and private sector.

The two main contributions we made in this paper are as follows:

1. Explore the government's and private sector's actions to facilitate MaaS development;
2. Develop indicators to assess equity aspects from adopting MaaS cases in Japan.

Each project head was interviewed about their equity implications, views, and perceptions. A deep interview was conducted with the local government regarding their role, legislation, and funding.

To evaluate societal impacts, we first tried to define a socially equitable transport system and Japan's current equity situation and history. In our definition, practical applications of measuring equity are accessibility, affordability, and inclusivity as equity objectives. Therefore, this study chose six equity indicators to achieve accessible, affordable, and inclusive equity objectives with MaaS in Japan.

The interviews revealed different concerns related to practical equity implications, although there were few differences between the two MaaS cases. In the MaeMaaS interview, operators-initiated interviews to prioritize the needs of older people and people with disabilities. Moreover, MaeMaaS collaborated with commercial facilities and operated buses with grocery

stores inside. On the other hand, Shizuoka MaaS has not collaborated with commercial facilities.

> "*We organized study groups with the citizens and other departments to increase participation from different stakeholders. We also started collaborating with commercial facilities to have incentives that private vehicles don't have. We initially collaborated with individual stores and are now in cooperation with a group of restaurants to increase trips for Maebashi citizens using the MaeMaaS service."* (MaeMaaS)

Another example of improving public engagement to reach different destinations that enable people to participate in the community's economic, political, and social life is with Shizuoka MaaS, where they collaborated with the citizens' public hall (kominkan*). Shopping for groceries is an activity that is highly related to managing and being in control of everyday life and possibly increasing the quality of life (Hjorthol, 2013).

*Kominkan - a kind of Japanese cultural center that provides structured learning programs in arts, sports, handiwork, and cultural activities to children, the youth, and the elderly. They are generally funded and administered by local governments.

> *"One of the major mobility issues is grocery shopping for areas with low public transportation accessibility, where the nearest station is 20–30 km away. We collaborated with the citizens' public hall to allow people to do online grocery shopping. This online shopping service has been successful, and we plan to expand the service to food or shopping trucks."* (Shizuoka MaaS)

This shows that privately operated MaaS projects in Japan collaborate well with the public sector in supporting the local citizens' daily mobility and promote their services. Besides, Shizuoka City local government and the Shizuoka City Council of Social Welfare are the participating organizations that make it possible to cooperate with them to promote and support Shizuoka MaaS.

"Additionally, we cooperate with the City Council of Social Welfare in the rural areas to promote Shizuoka MaaS. It's a nonprofit organization, and people can get any information related to Shizuoka MaaS." (Shizuoka MaaS)

The MaaS service must provide access to reliable and effective travel information. The Shizuoka MaaS has taken initiatives to share the information of their service through government organizations to engage with more people. The lack and uncertainty of new mobility services can certainly push people from using the service. Moreover, older people and children tend to be unfamiliar with app-based mobility services; thus, both MaaS projects allow phone call reservations.

"The interface of the MaaS phone app is designed for ease of use. The call center operates 24 hours, which makes it possible to use without any dedicated phone apps. Older people often use the call center; however, we also encourage them to use the app by talking with them and instructing them step-by-step." (MaeMaaS)

"Shizuoka MaaS started a call center service last year, although there are cases where people still go to the center to make reservations. Wider information is accessible on the MaaS app, not just the timetable, because we believe providing information is crucial when we start a new mobility system." (Shizuoka MaaS)

Likewise, we explored the physical accessibility of each of the MaaS cases and their planning from the universal design perspective. For our interview, accessibility refers to a wide range of factors, including the ease of travel in terms of time, physical accessibility to train stations and bus stops, and the financial ease of public transportation. It was mentioned that Shizuoka City aims to provide local public transportation services that anyone can use safely, securely, and comfortably in the regional public transportation network formation plan. We further asked their views on the statement.

"Main MaaS users are retired drivers and parents who bring their kids to school / prep school. Therefore, we reduced the fare system for older people and kids. Central or major stations have made general improvements. The integration between the existing bus network and the on-demand service is essential. We haven't collaborated commercial facilities yet, but we designed parking lots at bus stops to encourage park-and-ride."

*"Regarding physical accessibility, waiting areas are equipped with the requirements. There are *dedicated taxi services for people with physical constraints. However, it's not related to MaaS, and public transport in Shizuoka is accessible for people on wheelchairs."* (Shizuoka MaaS)

*Dedicated wheelchair-accessible taxi services are often found in Japan, and it is subsidized by the local city. However, barrier-free taxi services are facing a financial burden because the vehicles are often expensive, and it is costly to train the taxi drivers.

In Maebashi, the Gunma prefecture is highly car dependent, but MaeMaaS initiated various types of multimodal planning in their service.

"For example, collaborating with commercial facilities and providing real-time information. Furthermore, we are consolidating on-demand transport as the last mile while the axis bus routes are concentrated around JR Maebashi Station. We are also introducing a cycle-and-bus ride system. The Run-Run bus makes it possible to connect with existing bus routes to have fewer transfers between services. There are grocery shuttles in operation, making it easy to access basic activities linked to mobility, and the citizens have successfully used it.

On-demand buses are not accessible to wheelchair customers. MaeMaaS is not linked or integrated with the dedicated taxi services." (MaeMaaS)

Lastly, we examined whether each MaaS project has implemented a solution that fits their city archetype and resolves equity problems. However, it is seen that both MaaS projects are still under consideration for future developments.

> "*Discussion has started recently*." (MaeMaaS)
>
> "*Remote shopping was successful. Move the stores to the rural area or implementing grocery shuttle trucks and buses."* (Shizuoka MaaS)

CHAPTER 8 Discussion

8.1 Equity considerations in transport field

We identified that equity considerations should be discussed depending on the country or city, cultural characteristics, and archetype conditions. Therefore, it is crucial to develop equity indicators that are tailored and customized to the specific local conditions. Therefore, we discussed equity context in other counties such as United States, Europe, and United Kingdom. It was clear that equity in transportation context is defined and prioritized in the planning case by USDOT as well as Social Exclusion Unit in UK. Furthermore, numerous studies have been conducted on the historical pattern of racialization in infrastructure investment within the United States. The similar pattern is also seen in transportation sector hence, USDOT clarifies Equity action plan, comprehensive approach to advancing equity for all. Lower income people spend a far greater percent of their income on transportation than middle-income or high-income households. Income and wealth disparities is a critical problem which leads to lack of transportation options and job accessibility.

Although, equity is not clearly defined and studied in Japan, we discovered equity related considerations. It is found that government is prioritizing the social implementation to get social acceptance by the community to meet society's needs. Japan is often considered a homogeneous country with a population that is predominantly Japanese (97.8% according to census statistics in 2018), which can make issues of race and ethnicity less salient in transportation planning. However, gender and age-based disparities remain significant concerns, particularly due to Japan's rapidly ageing population. Moreover, the country has fare reduction programs for older people and individuals with disabilities with public transportation and taxi service. Furthermore, Japan has well-developed guidelines and standards for barrier-free design around public transportation area. However, we found that most AI on-demand

buses are not accessible for people with wheelchair and MaaS service itself was not integrated with the wheel-chair accessible taxi service.

This study conducted deep literature research on equity indicators and different approach of assessing equity. Accessibility was mostly used in measuring equity and works as a main indicator for equity. Measuring equity through accessibility is crucial, but it is equally important to consider which accessibility approach is being used as it can greatly impact the effectiveness of achieving equity. The person-based accessibility metrics take into account how transport and location characteristics interact with personal characteristics such as age, gender, and physical capacity to influence a person's accessibility levels. Therefore, combining place-based and person-based was recommended in this study.

Equity considerations in Japan is highly related to older people's mobility therefore, we also studied older people's mobility and found that it's crucial to study their well-being, social isolation levels, satisfaction with their life and out-of-home activities.

8.2 Accessibility and unmet transport needs

Car usage was extremely high in Shobara for both activity for shopping and hospital (89%, 91%). Shopping was the activity that most people want to do more often regardless of age. It may because shopping is a "basic" activity, and it can be seen as whether someone is in control of their everyday life. At the same time, satisfaction with shopping was the highest compared to other out-of-home activities and women were satisfied than man. It may show that people who are satisfied with certain activities wants to do that activity more than other type of activities. Therefore, it is important to understand their needs and implement new transport options to fill those gaps.

Moreover, car accessibly was higher than other transport modes for both person- and place-based measures. According to person- and place-based accessibility measures, transportation is less accessible to the elderly than the young and middle-aged. Specifically,

people who are worried about their driving ability had less accessibility by bus and walking compared to car accessibility. In addition, research has found that individuals who are feeling concerned or worried about their daily movement after 10 years also experienced reduced accessibility to walking and bus, but not to car transportation. This suggests that while older people have reduced accessibility to walking and bus, yet almost no difference in car accessibility. It may because older people rely on their family members to pick them up even though they are not able to drive or have limited mobility.

AI on-demand shuttle bus was not accessible as private cars however, compared to a regular bus, the AI on-demand shuttle bus results in a remarkable decrease in the accessibility inequity. Furthermore, more than two third of the older people answered that AI on-demand bus can stop near to their house and made AI on-demand bus easy to use. If we compare it to regular bus, AI on-demand bus can offer more door-to-door accessibility and more flexible schedule. This may also relate to why the users deemed the schedule suitable for them. However, older people found making reservations was troublesome or difficult even though reservations can be made by phone calls. It suggests perhaps older people are not adaptable or familiar with the new service. Furthermore, receiving "Horoka", bonus points when using MaaS was attracted more users than implementing unlimited ride shows that Japanese people are more common in using points in their daily lives. For those reasons, respondents answered that their out-of-home activities are likely to increase (56%) with AI on-demand bus.

Typically, older residential properties are situated along narrow streets and it is observed that buses do not consistently operate near residential areas. However, when new bypasses are constructed, bus routes are often designed to align with those new roadways. Consequently, buses primarily run their services along these new roads, resulting in a long distance between bus stops and residential dwellings. AI on-demand transportation provides a convenient solution by flexible and convenient stops which eliminates the need for people to walk long

distances to reach a traditional bus stop. MaaS initiative in Shobara endeavors to enhance the accessibility of public transportation while simultaneously addressing concerns surrounding fare resistance through the implementation of subscription-based fare structures.

8.3 Older people's well-being measure

The discussion on different types of well-being, namely subjective and objective well-being, was included in the study to provide a contextual background. The well-being measures used in the study provide both subjective and objective perspectives of well-being. Social isolation was particularly important in providing an objective perspective on well-being since it is not solely based on a person's attitudes or mental state. We mentioned that several studies focused on subjective well-being, while objective well-being was less discussed. When we look closely to whether car ownership has influence on well-being measure, the study found significant differences. People who had access to car had low social isolation level (42%) however, those who are not had extremely socially isolated (96%). We also find similar difference in freedom to go out and it shows that car ownership has highly correlated to older people's daily activity. However, it's important to distinguish between older individuals who have car yet are don't drive. This category allowed us to see the difference between older people who no longer can drive or who have never had driving license. Interestingly, there is almost no difference in social isolation between those who have a car but cannot drive and those who do not have a car at all. For instance, there may be cases where a woman has a car in the household but cannot drive or no longer has the ability to drive.

Those over 80 or 90 years old had much higher social isolation which explains that they often live alone and have less contact with their family and friends. It also shows that why they were not satisfied with their out-of-home activities compared to other age groups. Specifically, 90% of the people who are over 90+ had high social isolation and more than half of them answered that they don't have freedom to go out anytime they want while less than 10% of the

people who are 50-69 years old answered they need help to go out. Therefore, older people's independence is highly linked to their age and there is a significant difference in their social isolation level between people who are only 20-30 years apart in age. It is also worth to aid that we need to focus on people who are in certain age groups instead of defining anyone 60 years or older as older person.

8.4 Equity implications

MaeMaaS collaborated with commercial facilities such as individual stores and group of restaurants and operated buses with grocery stores inside which shows that local government take actions on engaging the public with their MaaS service. On the other hand, Shizuoka MaaS not collaborated with commercial facilities, yet they also collaborated with the citizens' public hall to offer remote shopping for citizen. This shows that even privately operated MaaS services are trying to cooperate with the local organizations in order to attract users and engage with the local citizens. The local government operates MaeMaaS, and it is shown that the city tries to listen to the needs of underserved communities.

Both MaaS tried to improve the integration between the stations and MaaS service to increase the accessibility. For example, MaeMaaS designed parking lots at bus stops to encourage park-and-ride and central or major stations have made general improvements and waiting areas for Shizuoka MaaS are equipped with the requirements. However, both on-demand buses are not accessible to people with wheelchair and not integrated with the dedicated wheelchair-accessible taxi services. Some of the dedicated wheel-chair accessible bus or taxi services are operated by hospital staff which is free for service. However, privately operated barrier-free taxi services are facing a financial burden because the vehicles are often expensive, and it is costly to train the taxi drivers. Therefore, one practical implication would be integrating privately operated barrier-free taxi into the MaaS service to make the service more accessible for people with special needs.

We chose multimodal planning as an equity indicator since concept of MaaS also considers and integrates various modes. MaeMaaS is introducing and park-and-bus ride and cycle-and-bus ride system and better bus routes to connect with the existing bus network. We noted that both MaaS cases are still at early stage of integrating their services with different transport modes. Furthermore, equity implications or indicators that were not prioritized were considered. Therefore, we noted the importance of the institutional organization structure for developing MaaS to bring together the private and public sectors on board.

Private operators can play a crucial role in prioritizing equity in the transport sector by implementing various strategies and initiatives. Firstly, private operators can propose a fare structure that is affordable for everyone through the MaaS bundle, ensuring that transportation remains accessible to marginalized communities. Secondly, private operators can invest in and maintain accessible vehicles that cater to individuals with mobility challenges, ensuring that everyone, regardless of their physical abilities, can use their services. Thirdly, private operators can work towards seamless integration between different modes of transport (e.g., buses, trains, rideshare) to provide convenient and cost-effective options for commuters, making it easier for people to choose public transportation. Lastly, private operators can engage with local communities to understand their unique transportation needs and concerns and incorporate their feedback into service planning and improvement efforts.

Based on our survey we indicated that central government doesn't have incentives on prioritizing equity implications when planning MaaS service in Japan. Central government enforced laws and regulations for transport operators to implement barrier-free design to increase access to opportunities for people with disabilities however, equity is not addressed. At the same time, local government lacking financial, knowledge and technology resources to tackle equity issues especially small and medium sized local governments.

CHAPTER 9 Conclusions and Recommendations

9.1 Summary of findings

Japan's rural mobility has been long in decline and inefficient in many areas which leads to increase in MaaS projects in rural areas of Japan. A notable increase is evident in MaaS projects in Japan, especially in rural areas, to revitalize local transport and tackle current mobility issues. Although we need to understand the travel needs of citizen, examine how MaaS can be expanded, and clarify its effects on improving the social equity of people. Many mobility projects and services aim to fill the unmet needs of underserved communities in Japan. Earlier, we mentioned community buses and taxis for small-scale demand for community transportation and alternative private cars for those who cannot drive or do not have access to a car. Similarly, most Japanese MaaS adaptations aim to maintain local transport in cooperation with tourist and commercial facilities.

Chapter 5 found that transportation is less accessible to the elderly than the young and middle-aged in Shobara according to person- and place-based accessibility measures. Therefore, the study did not solely focus on older people's accessibility instead we tried to compare different age groups. Nevertheless, compared to a regular bus, the AI on-demand shuttle bus results in a remarkable decrease in the accessibility inequity for two out-of-home activities and seems to benefit almost all Shobara areas. Overall usage of regular bus and community sharing taxi was extremely low and several barriers have been discovered in chapter 5. It was determined that public transportation is insufficient, and that older people do not find it convenient to go shopping using public transit. Chapter 6 concluded that the planning of AI on-demand bus stops was suitable for most users, as much as older people, to do shopping, given their proximity to commercial places. The schedule was rated adequate by more than half of the users, although 50% of older individuals found it challenging or difficult to make

reservations. According to user feedback, offering bonus points instead of an unlimited pass appeared to have a more impactful in increasing people's usage of AI on-demand buses.

In Chapter 6, it was discovered that shopping was the most desired activity among people of all ages, followed by going out to eat and visiting family and friends, with each activity being preferred by 16% of the respondents. However, results showed a notable difference by sex group. In most cases, women preferred more activities than men, including going shopping, exercising, and visiting friends and family. Well-being measures were only focused on older people. Furthermore, few only a small percentage of respondents wanted to increase their frequency of hospital visits, showing how important health is for older people.

In Chapter 6, the SEM analysis revealed a significant correlation between well-being and the variables of freedom to go out, satisfaction with life, and activity. Satisfaction with out-of-home activities has the most significant effect on satisfaction with life. However, social isolation has no significant impact on satisfaction with life which might shows that older people in Shobara depend on their family and friends for daily necessities did not impact how much they are socially excluded. However, participation in social activities, organizations, and events showed a significant correlation with social isolation, suggesting that older people feel more socially included if they are part of a community or group. Nevertheless, well-being can be measured in terms of freedom to go out and satisfaction with life and activity. We mentioned several studies that examined well-being from an equity perspective. Social isolation was particularly important in providing an objective perspective on well-being since it is not solely based on a person's attitudes or mental state. Levels of subjective well-being experienced by commuters using different transport modes and show how these levels of subjective well-being can be analyzed in relation to different demographics in order to understand the equity implications (Reardon, 2019). Therefore, we measured levels of well-being among different

social groups to analyze it from an equity perspective. The rest of the results are from explanatory analysis.

When examined through an equity lens, with well-being linked to socioeconomic status.

- Of those respondents who have access to a car had significantly higher freedom to go out than those who are not, which also relates to lower satisfaction and social isolation level.
- Measures of well-being were correlated and lower for individuals without car access and older age groups.
- Those over 80 or 90 years old had high social isolation levels and were not as satisfied with their out-of-home activities as the other age groups.
- Similarly, they needed help to go out, showing that fulfilling daily activities was challenging for their age bracket

The findings from the interviews in Chapter 7 indicate that equity is not highly or may not even be prioritized by both MaaS cases. The privately operated Shizuoka MaaS facilitator stated that they are already experiencing driver shortage issues and decreased demand; therefore, equity concerns come after. Maebashi City mentioned that the local government started to interview operators about the elderly and people with disabilities. It is implied that the government, private industries, and other collaborative parties must work together to involve a wide range of equity concerns and actively engage with customer needs to create more accessible, affordable, and inclusive mobility solutions. The central government should create new incentives that support equitable MaaS solutions, not only through funding but also through facilitative legislation and other measures, such as an incentive that increase access to opportunities for people with disabilities or low-income people. Local governments should carefully formulate a transportation plan for equitable MaaS and create an environment where private companies can prioritize equity issues and ensure access to all mobility services for all

persons by establishing a comprehensive local transportation plan. Each MaaS has its characteristics and goals; therefore, the equity strategy must be grounded and tailored to local conditions. After all, local governments are successors to the equitable MaaS service.

MaeMaaS, where the city oversees facilitating the MaaS service, collaborated with several different commercial facilities to increase engagement and support multimodal planning. In terms of multimodal planning, MaeMaaS has initiated a cycle-and-bus ride system, the development of the on-demand bus network, and grocery shuttles, which aim to serve people who have difficulties in grocery shopping. One of the takeaways was how MaeMaaS also introduced discounted fares for Maebashi citizens based on citizen authentication cards (my number card), which allows local affordable services for local people. On the other hand, Shizuoka MaaS has not cooperated with commercial facilities, yet they initiated a remote shopping service that can be done from the citizens' public hall. Fare is reduced for older people and children. In addition, the central station has made general improvements, including park-and-ride services at bus stops.

Both MaaS cases operate a dedicated phone app and a call center where people can make reservations without time restrictions. The latter is especially critical for people not exposed to smartphone apps. Moreover, city officials are a big help, especially for older people, to use MaeMaaS and Shizuoka MaaS works with the City Council of Social Welfare to promote their service, as such initiatives help remove information-related barriers. As the accessibility-related result shows, there are very few initiatives in both MaaS services. New implemented on-demand buses under the MaaS service are not accessible for people who use wheelchairs, showing that universal design was not fully considered and planned, even though all the buses and trains are barrier-free in Japan.

By addressing equity implications of two different MaaS cases developed and implemented by both government and private sector, we were able to give some

recommendations for the MaaS facilitator. Local governments should carefully formulate a transportation plan for equitable MaaS and create an environment where private companies can prioritize equity issues and ensure access to all mobility services for all persons by establishing a comprehensive local transportation plan. Local governments are successors to the equitable MaaS service. On the other hand, the central government should create new incentives that support equitable MaaS solutions, not only through funding but also through facilitative legislation and other measures, such as an incentive that increase access to opportunities for people with disabilities or low-income people. Motivating transport operators to prioritize equity issues involves creating awareness, fostering a sense of responsibility, and implementing effective strategies. Most importantly highlighting the benefits of prioritizing equity issues for transport operators. It is important to explain how inclusive services can attract a broader customer base, enhance customer satisfaction, and improve their reputation which potentially lead to increased ridership and revenue in the long run. In addition, rearranging transport service in systematic way can increase efficiency which results in reduced cost.

Chapter 8 delved into the prioritization of equity implications within the transport field, highlighting the unique aspects of Japan in comparison to other cases. The chapter went on to analyze the practical approaches taken by two different MaaS cases in Japan, emphasizing the consideration given to equity implications by their main bodies. Then the accessibility level of different modes and MaaS service is studied and compared within different social groups. Depth analysis on MaaS usage and users' perception as well as viewpoint investigated. Overall, this chapter wrap ups and conducted in-depth investigation on previous chapter's findings and summary.

Finally, MaaS in Japan is still under development, and MaaS cases led and developed by the government and private sector, respectively, have their differences and similarities. From our results, we suggest that it is vital to come to a common understanding of equity issues and

prioritize it at all public and private sector levels. Moreover, accessibility should be a core measure when implementing new mobility options like MaaS services. Equitable mobility can succeed when we create solutions that work for each city archetype. Therefore, it is necessary to make more grounded and tailored solutions.

9.2 Future research directions

More attention to MaaS from an equity perspective would contribute to equal accessibility distribution, facilitating a more comprehensive implementation of MaaS adoption in depopulated areas. Older people living alone and having difficulty with physical activity may not be able to rely on private cars; thus, the AI on-demand bus resulted in greater accessibility for these people. Hence, further investigation of the accessibility of the AI on-demand bus with respect to other essential nonwork activities from an equity framework must be conducted. From these results, it can be said that developing MaaS projects that respond to the characteristics of rural areas and reconstructing transport issues based on accessibility measures are necessary for multiple regions of rural Japan.

The findings highlight that more research must be carried out on new mobility systems' impact on well-being needs in terms of fulfilling the unmet needs of older people and unsatisfied out-of-home activities. This recommendation considers that we will live longer after retirement compared to previous generations of pensioners. This study also showed several significant differences among age groups. It is important to note that the well-being approach requires addressing inequities in well-being by working across boundaries that older people experience in day-to-day life. In other words, further studies should initiate a discussion about what is essential for older people concerning transport and use the perspectives of objective and subjective well-being in inequities. Further investigation of the usage of AI on-demand buses, as well as the possible impact on older people's well-being, might help to assess

the development of these new transport services that effectively meet the needs or desired activities in later life.

We did not conduct an examination of individual levels of transport equity; rather, our study focused on population groups. Nevertheless, it is imperative for future research to investigate individual equity levels as well.

From our results, we suggest that it is vital to come to a common understanding of equity issues and prioritize it at all public and private sector levels. Moreover, accessibility should be a core measure when implementing new mobility options like MaaS services. One practical implication is integrating community taxis into the MaaS service to make the service more accessible for people with special needs. Equitable mobility can succeed when we create solutions that work for each city archetype. Therefore, it is necessary to make more grounded and tailored solutions.

References

Aapaoja, A., Eckhardt, J., Nykänen, L., & Sochor, J. (2017). *MaaS service combinations for different geographical areas*. 12.

Aarhaug, J., & Elvebakk, B. (2015). The impact of Universally accessible public transport–a before and after study. *Transport Policy*, *44*, 143–150. https://doi.org/10.1016/j.tranpol.2015.08.003

Abdelwahab, B., Palm, M., Shalaby, A., & Farber, S. (2021). Evaluating the equity implications of ridehailing through a multi-modal accessibility framework. *Journal of Transport Geography*, *95*, 103147. https://doi.org/10.1016/j.jtrangeo.2021.103147

ABeam. (2019). *MaaS (Mobility-as-a-Service): The Nature of MaaS. easily*, 32.

Adorno, G., Fields, N., Cronley, C., Parekh, R., & Magruder, K. (2018). Ageing in a low-density urban city: Transportation mobility as a social equity issue. *Ageing and Society*, *38*(2), 296–320. https://doi.org/10.1017/S0144686X16000994

APTA. (2019). *Being Mobility-as-a-Service (MaaS) Ready*. APTA International Study Mission.

Akagi, D., Kanda, Y., Morohoshi, K. (2021). Empirical study on design and social implementation of rural MaaS, J. *Jpn. Soc. Civ. Eng. Ser*. D3. (Infrastruct. Plan. Manag.). 76, 1197–1208. https://doi.org/10.2208/jscejipm.76.5_I_1197.

Akiyama, T., Kamata, M., Wahira, Y., et al. (2001). Vehicle accessibility in Japan today and the outlook for the future. *IATSS Research*. 25(1), 42–50. https://doi.org/10.1016/S0386-1112(14)60005-4.

Alves, F., Cruz, S., Ribeiro, A., Silva, A.B., Martins, J., Cunha, I. (2020). Walkability index for elderly health: A proposal. *Sustain*. 12, 7360. https://doi.org/10.3390/su12187360.

Arsenio, E., Martens, K., Ciommo, F. Di. (2016). Sustainable urban mobility plans: Bridging climate change and equity targets?, *Res. Transp. Econ.* 55, 30–36. https://doi.org/10.1016/j.retrec.2016.04.008.

Arai, A., Mizuno, Y., & Arai, Y. (2011). Implementation of municipal mobility support services for older people who have stopped driving in Japan. *Public Health*, *125*(11), 799–805. https://doi.org/10.1016/j.puhe.2011.09.016

Aristotle. (1980, January 1). *Aristotle: The Nicomachean Ethics (Revised Edition)*. Oxford University Press. https://oxfordscholarlyeditions.com/view/10.1093/actrade/9780199213610.book.1/actrade-9780199213610-book-1

Arsenio, E., Martens, K., & Di Ciommo, F. (2016). Sustainable urban mobility plans: Bridging climate change and equity targets? *Research in Transportation Economics*, *55*, 30–39. https://doi.org/10.1016/j.retrec.2016.04.008

Ashraf Javid, M., Abdullah, M., Ali, N., & Dias, C. (2021). Structural equation modeling of public transport use with COVID-19 precautions: An extension of the norm activation model. *Transportation Research Interdisciplinary Perspectives*, *12*, 100474. https://doi.org/10.1016/j.trip.2021.100474

Audouin, M., & Finger, M. (2018). The development of Mobility-as-a-Service in the Helsinki metropolitan area: A multi-level governance analysis. *Research in Transportation Business & Management*, *27*, 24–35. https://doi.org/10.1016/j.rtbm.2018.09.001

Bach, X., Marquet, O., & Miralles-Guasch, C. (2023). Assessing social and spatial access equity in regulatory frameworks for moped-style scooter sharing services. *Transport Policy*, *132*, 154–162. https://doi.org/10.1016/j.tranpol.2023.01.002

Bartzokas-Tsiompras, A., & Photis, Y. N. (2019). Measuring rapid transit accessibility and equity in migrant communities across 17 European cities. *International Journal of*

Transport Development and Integration, *3*(3), 245–258. https://doi.org/10.2495/TDI-V3-N3-245-258

Basic Registered Residents – Population and the Number of Households, (2021), Shobara City, http://www.city.shobara.hiroshima.jp/main/government/statistics/jinko.html.

Behbahani, H., Nazari, S., Jafari Kang, M., & Litman, T. (2019). A conceptual framework to formulate transportation network design problem considering social equity criteria. *Transportation Research Part A: Policy and Practice*, *125*, 171–183. https://doi.org/10.1016/j.tra.2018.04.005

Berg, J., Levin, L., Abramsson, M., & Hagberg, J.-E. (2015). "I want complete freedom": Car use and everyday mobility among the newly retired. *European Transport Research Review*, *7*(4), 31. https://doi.org/10.1007/s12544-015-0180-6

Bergstad, C. J., Gamble, A., Gärling, T., Hagman, O., Polk, M., Ettema, D., Friman, M., & Olsson, L. E. (2011). Subjective well-being related to satisfaction with daily travel. *Transportation*, *38*(1), 1–15. https://doi.org/10.1007/s11116-010-9283-z

Boisjoly, G., Serra, B., Oliveira, G., El-Geneidy, A. (2020). Accessibility measurements in São Paulo, Rio de Janeiro, Curitiba and Recife, Brazil, *J. Transp. Geogr*. 82, 1–11. https://doi.org/10.1016/j.jtrangeo.2019.102551.

Burton, E., Mitchell, L. (2006). Inclusive Urban Design: Streets for Life, Elsevier, Oxford.

Butler, L., Yigitcanlar, T., & Paz, A. (2021). Barriers and risks of Mobility-as-a-Service (MaaS) adoption in cities: A systematic review of the literature. *Cities*, *109*, 103036. https://doi.org/10.1016/j.cities.2020.103036

Byrne, B. M. (2016). *Structural equation modeling with Amos: Basic concepts, applications, and programming (3rd edition).* https://doi.org/10.4324/9780203805534

Cao, J. (2013). The association between light rail transit and satisfactions with travel and life: Evidence from Twin Cities. *Transportation*, *40*(5), 921–933. https://doi.org/10.1007/s11116-013-9455-8

Cao, M., Zhang, Y., Zhang, Y., Li, S., & Hickman, R. (2019). Using different approaches to evaluate individual social equity in transport. In R. Hickman, B. Mella Lira, M. Givoni, & K. Geurs, *A Companion to Transport, Space and Equity* (pp. 209–228). Edward Elgar Publishing. https://doi.org/10.4337/9781788119825.00024

Casadó, D. G. R. G., Karen Laing, R. P., & Liz Todd. (2020). *Children, Young people and Mobility as a Service Opportunities and barriers for future mobility*. http://dx.doi.org/10.1016/j.trip.2020.100107

Chakrabarti, S., Hamlet, L. C., Kaminsky, J., & Subramanian, S. V. (2021). Association of Human Mobility Restrictions and Race/Ethnicity–Based, Sex-Based, and Income-Based Factors With Inequities in Well-being During the COVID-19 Pandemic in the United States. *JAMA Network Open*, *4*(4), e217373. https://doi.org/10.1001/jamanetworkopen.2021.7373

Cochran, A. L., & Chatman, D. G. (2021). Use of app-based ridehailing services and conventional taxicabs by adults with disabilities. *Travel Behaviour and Society*, *24*, 124–131. https://doi.org/10.1016/j.tbs.2021.02.004

City of Dallas, (2017). Transportation Equity and Access to Opportunity for Transit-Dependent Population in Dallas, Mobility Solutions, Infrastructure and Sustainability Committee

Cui, B., Boisjoly, G., El-Geneidy, A., Levinson, D. (2019). Accessibility and the journey to work through the lens of equity. *J. Transp. Geogr*. 74, 269–277. https://doi.org/10.1016/j.jtrangeo.2018.12.003.

Deakin, E., & Smart, M. (2003). Access to employment and services: A review of the transport-related literature. *Transport Policy*, 10(2), 95-111.

De Vos, J., Schwanen, T., Van Acker, V., & Witlox, F. (2013). Travel and Subjective Well-Being: A Focus on Findings, Methods and Future Research Needs. *Transport Reviews*, *33*(4), 421–442. https://doi.org/10.1080/01441647.2013.815665

Delbosc, A., & Currie, G. (2011). The spatial context of transport disadvantage, social exclusion and well-being. *Journal of Transport Geography*, *19*(6), 1130–1137. https://doi.org/10.1016/j.jtrangeo.2011.04.005

Di Ciommo, F., & Shiftan, Y. (2017). Transport equity analysis. *Transport Reviews*, *37*(2), 139–151. https://doi.org/10.1080/01441647.2017.1278647

Diener, E. (2009). Subjective Well-Being. In E. Diener (Ed.), *The Science of Well-Being: The Collected Works of Ed Diener* (pp. 11–58). Springer Netherlands. https://doi.org/10.1007/978-90-481-2350-6_2

Diener, E., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The Satisfaction With Life Scale. *Journal of Personality Assessment*, *49*(1), 71–75. https://doi.org/10.1207/s15327752jpa4901_13

Durand, A., Harms, L., Hoogendoorn-Lanser, S., & Zijlstra, T. (n.d.). *Mobility-as-a-Service and changes in travel preferences and travel behaviour: A literature review*. 57.

El-Geneidy, A., Levinson, D., Diab, E., Boisjoly, G., Verbich, D., & Loong, C. (2016). The cost of equity: Assessing transit accessibility and social disparity using total travel cost. *Transportation Research Part A: Policy and Practice*, *91*, 302–316. https://doi.org/10.1016/j.tra.2016.07.003

Enoch, P. M. (n.d.). *Mobility as a Service (MaaS) in the UK: change and its implications*.

Eppenberger, N., & Richter, M. A. (2021). The opportunity of shared autonomous vehicles to improve spatial equity in accessibility and socio-economic developments in European

urban areas. *European Transport Research Review*, *13*(1), 32. https://doi.org/10.1186/s12544-021-00484-4

Ettema, D., Gärling, T., Olsson, L. E., & Friman, M. (2010). Out-of-home activities, daily travel, and subjective well-being. *Transportation Research Part A: Policy and Practice*, *44*(9), 723–732. https://doi.org/10.1016/j.tra.2010.07.005

Ferdman, A. (2021). Well-being and mobility: A new perspective. *Transportation Research Part A: Policy and Practice*, *146*, 44–55. https://doi.org/10.1016/j.tra.2021.02.003

Fiedler, M., & Consult, R. (2007). Challenges and Chances of an Ageing Society. *Public Transport*, 116.

Fransen, K., & Farber, S. (2019). Using person-based accessibility measures to assess the equity of transport systems. In *Measuring Transport Equity* (pp. 57–72). Elsevier. https://doi.org/10.1016/B978-0-12-814818-1.00004-4

Geurs, K. T., & van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: Review and research directions. *Journal of Transport Geography*, *12*(2), 127–140. https://doi.org/10.1016/j.jtrangeo.2003.10.005

Giesel, F., & Köhler, K. (2015). How poverty restricts elderly Germans' everyday travel. *European Transport Research Review*, *7*(2), 15. https://doi.org/10.1007/s12544-015-0164-6

Gilroy, R. (2008). Places that Support Human Flourishing: Lessons from Later Life. *Planning Theory & Practice*, *9*(2), 145–163. https://doi.org/10.1080/14649350802041548

Golub, A., Satterfield, V., Serritella, M., Singh, J., & Phillips, S. (2019). Assessing the barriers to equity in smart mobility systems: A case study of Portland, Oregon. *Case Studies on Transport Policy*, *7*(4), 689–697. https://doi.org/10.1016/j.cstp.2019.10.002

Goralzik, A., König, A., Alčiauskaitė, L., & Hatzakis, T. (2022). Shared mobility services: An accessibility assessment from the perspective of people with disabilities. *European Transport Research Review*, *14*(1), 34. https://doi.org/10.1186/s12544-022-00559-w

Gordon, C., & Tanton, R. (2013). Incorporating Measures of Subjective Well Being into the Measurement of Transport Equity. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2389849

Grengs, J., Levine, J., & Shen, Q. (2013). *Evaluating Transportation Equity: An Intermetropolitan Comparison of Regional Accessibility and Urban Form*.

Grengs, J. (2015). Nonwork accessibility as a social equity indicator. *Int. J. Sust. Transp*. 9, 1–14. https://doi.org/10.1080/15568318.2012.719582.

Guers, K. (2020). *Accessibility and Transport Appraisal: Approaches and Limitations* (International Transport Forum Discussion Papers No. 2020/22; International Transport Forum Discussion Papers, Vol. 2020/22). https://doi.org/10.1787/58a96ff1-en

Hair, J. F., Black, W. C., & Babin, B. J. (2010). *Multivariate Data Analysis: A Global Perspective*. Pearson Education. https://books.google.co.jp/books?id=SLRPLgAACAAJ

Handy, S. (2020). Is accessibility an idea whose time has finally come?. *Transp. Res. Part D Transp*. Environ. 83, 102319. https://doi.org/10.1016/j.trd.2020.102319.

Hansen, W. (1959). How accessibility shapes land use. *J. Am. Inst. Plan*. 25, 73–76. https://doi.org/10.1080/01944365908978307

Haybron, D. M. (2011). Taking the satisfaction (and the life) out of life satisfaction. *Philosophical Explorations*, *14*(3), 249–262. https://doi.org/10.1080/13869795.2011.594959

Hirschhorn, F., Paulsson, A., Sørensen, C. H., & Veeneman, W. (2019). Public transport regimes and mobility as a service: Governance approaches in Amsterdam, Birmingham, and Helsinki. *Transportation Research Part A: Policy and Practice*, *130*, 178–191. https://doi.org/10.1016/j.tra.2019.09.016

Hjorthol, R. (2013). Transport resources, mobility and unmet transport needs in old age. *Ageing and Society*, *33*(7), 1190–1211. https://doi.org/10.1017/S0144686X12000517

Inspirata. (2019), MaaS: The Mobility Revolution Coming to North America. https://www.inspiratia.com/uploads/public/maas-the-mobility-revolution-coming-to-north-america.pdf

Intelligent Transport. (2022), Developing the UK's first multi-city MaaS platform, (accessed 14 March 2023).

ITF. (2021). The Innovative Mobility Landscape: The Case of Mobility as a Service. *OECD Publishing, Paris*, *No. 92*, 128.

Izumiyama, H., Ohmori, N., Harata, N. (2007). Space-time accessibility measures for evaluating mobility-related social exclusion of the elderly, in: 11th International Conference on Mobility and Transport for Elderly and Disabled Persons (TRANSED): Benchmarking, Evaluation and Vision for the Future.

Jackson, S. E., Firth, J. A., Firth, J., Veronese, N., Gorely, T., Grabovac, I., Yang, L., & Smith, L. (2019). Social isolation and physical activity mediate associations between free bus travel and wellbeing among older adults in England. *Journal of Transport & Health*, *13*, 274–284. https://doi.org/10.1016/j.jth.2019.03.006

Jeddi Yeganeh, A., Hall, R., Pearce, A., & Hankey, S. (2018). A social equity analysis of the U.S. public transportation system based on job accessibility. *Journal of Transport and Land Use*, *11*(1). https://doi.org/10.5198/jtlu.2018.1370

Jittrapirom, P., Caiati, V., Feneri, A.-M., Ebrahimigharehbaghi, S., González, M. J. A., & Narayan, J. (2017). Mobility as a Service: A Critical Review of Definitions, Assessments of Schemes, and Key Challenges. *Urban Planning*, *2*(2), 13–25. https://doi.org/10.17645/up.v2i2.931

Jittrapirom, P., Marchau, V., van der Heijden, R., & Meurs, H. (2018). Dynamic adaptive policymaking for implementing Mobility-as-a Service (MaaS). *Research in Transportation Business & Management*, *27*, 46–55. https://doi.org/10.1016/j.rtbm.2018.07.001

Jones, P., & Lucas, K. (2012). The social consequences of transport decision-making: Clarifying concepts, synthesising knowledge and assessing implications. *Journal of Transport Geography*, *21*, 4–16. https://doi.org/10.1016/j.jtrangeo.2012.01.012

Kamargianni, M., Li, W., Matyas, M., & Schäfer, A. (2016). A Critical Review of New Mobility Services for Urban Transport. *Transportation Research Procedia*, *14*, 3294–3303. https://doi.org/10.1016/j.trpro.2016.05.277

Karen Lucas. (2012). *A critical assessment of accessibility planning for social inclusion*. Edward Elgar Publishing Ltd. https://doi.org/10.4337/9781781000113

Karen Lucas, Kees Maat, & Bert van Wee. (2015). *A method to evaluate equitable accessibility: Combining ethical theories and accessibility-based approaches*.

Karlsson, I. C. M., Mukhtar-Landgren, D., Smith, G., Koglin, T., Kronsell, A., Lund, E., Sarasini, S., & Sochor, J. (2020). Development and implementation of Mobility-as-a-Service – A qualitative study of barriers and enabling factors. *Transportation Research Part A: Policy and Practice*, *131*, 283–295. https://doi.org/10.1016/j.tra.2019.09.028

Karner, A., London, J., Rowangould, D., & Manaugh, K. (2020). From Transportation Equity to Transportation Justice: Within, Through, and Beyond the State. *Journal of Planning Literature*, *35*(4), 440–459. https://doi.org/10.1177/0885412220927691

Keller, E., Aguilar, A., & Hanss, D. (2018). Car Sharers' Interest in Integrated Multimodal Mobility Platforms: A Diffusion of Innovations Perspective. *Sustainability*, *10*(12), 4689. https://doi.org/10.3390/su10124689

Kimura, S. (2016). Community Development and Local Public Transportation Systems. 公益財団法人日本都市センター, *25／26*, 60.

Kim, J. (2018). What about People in Accessibility? A Comparative Analysis between Place-Based Accessibility and Person-Based Accessibility. APA Student Paper Competition: Master's Thesis, University of Illinois, Urbana-Champaign, IL, USA.

König, D., Eckhardt, J., & Aapaoja, A. et al. (2016). *Deliverable 3: Business and operator models for MaaS. MAASiFiE project funded by CEDR.* 81.

Litman, T. (2020). *Evaluation and Improvement Strategies*.

Litman, T. A. (2021). *Evaluating Transportation Equity*. 76.

Loos, E., Sourbati, M., & Behrendt, F. (2020). The Role of Mobility Digital Ecosystems for Age-Friendly Urban Public Transport: A Narrative Literature Review. *International Journal of Environmental Research and Public Health*, *17*(20), 7465. https://doi.org/10.3390/ijerph17207465

Lucas, K. (2006). Providing transport for social inclusion within a framework for environmental justice in the UK. *Transportation Research Part A: Policy and Practice*, *40*(10), 801–809. https://doi.org/10.1016/j.tra.2005.12.005

Lucas, K. (2012). Transport and social exclusion: Where are we now? *Transport Policy*, *20*, 105–113. https://doi.org/10.1016/j.tranpol.2012.01.013

Lucas, K., & Currie, G. (2012). Developing socially inclusive transportation policy: Transferring the United Kingdom policy approach to the State of Victoria? *Transportation*, *39*(1), 151–173. https://doi.org/10.1007/s11116-011-9324-2

Lucas, K., Wee, B. van, Maat, K. (2016). A method to evaluate equitable accessibility: combining ethical theories and accessibility-based approaches. *Transp*. 43, 473–490. https://doi.org/10.1007/s11116-015-9585-2.

Luiu, C., Tight, M., & Burrow, M. (2017). The unmet travel needs of the older population: A review of the literature. *Transport Reviews*, *37*(4), 488–506. https://doi.org/10.1080/01441647.2016.1252447

Luiu, C., Tight, M., & Burrow, M. (2018). Factors Preventing the Use of Alternative Transport Modes to the Car in Later Life. *Sustainability*, *10*(6), 1982. https://doi.org/10.3390/su10061982

Lyons, G., Hammond, P., & Mackay, K. (2019). The importance of user perspective in the evolution of MaaS. *Transportation Research Part A: Policy and Practice*, *121*, 22–36. https://doi.org/10.1016/j.tra.2018.12.010

Lyubomirsky, S., Sheldon, K. M., & Schkade, D. (2005). Pursuing Happiness: The Architecture of Sustainable Change. *Review of General Psychology*, *9*(2), 111–131. https://doi.org/10.1037/1089-2680.9.2.111

MaaS alliance. (2017). *Guidelines & Recommendations to create the foundations for a thriving MaaS ecosystem*. MaaS alliance.

Manaugh, K., Badami, M. G., & El-Geneidy, A. M. (2015). Integrating social equity into urban transportation planning: A critical evaluation of equity objectives and measures in transportation plans in North America. *Transport Policy*, *37*, 167–176. https://doi.org/10.1016/j.tranpol.2014.09.013

Martens, K. (2012). Justice in transport as justice in accessibility: Applying Walzer's "Spheres of Justice" to the transport sector. Transp. 39, 1035–1053. https://doi.org/10.1007/s11116-012-9388-7.

Martens, K., Bastiaanssen, J., & Lucas, K. (2019). 2—Measuring transport equity: Key components, framings and metrics. In K. Lucas, K. Martens, F. D. Ciommo, & A. Dupont-Kieffer (Eds.), *Measuring Transport Equity* (pp. 13–36). Elsevier. https://doi.org/10.1016/B978-0-12-814818-1.00002-0

Martens, K., Golub, A., & Robinson, G. (2012). A justice-theoretic approach to the distribution of transportation benefits: Implications for transportation planning practice in the United States. *Transportation Research Part A: Policy and Practice*, *46*(4), 684–695. https://doi.org/10.1016/j.tra.2012.01.004

McAuley, E., Konopack, J. F., Motl, R. W., Morris, K. S., Doerksen, S. E., & Rosengren, K. R. (2006). Physical activity and quality of life in older adults: Influence of health status and self-efficacy. *Annals of Behavioral Medicine*, *31*(1), 99–103. https://doi.org/10.1207/s15324796abm3101_14

Mizokami, S., Kawashima, H., Nagata, C., & Yaguchi, T. (2014). *Intervention Research for Quality of Life Improvement through the use of Personal Mobility Mode in an Aging Society*. *3*(1), 13.

Mori, E. H., & Anttiroiko, A.-V. (2022). *City, Public Value, and Capitalism*. 307.

MLIT, Japan. National Integrated Transport Analysis System (NITAS).

Ministry of Infrastructure and Water Management (2019) (accessed 14 March 2021).

Mulley, C., & Kronsell, A. (2018). Workshop 7 report: The "uberisation" of public transport and mobility as a service (MaaS): Implications for future mainstream public transport. *Research in Transportation Economics*, *69*, 568–572. https://doi.org/10.1016/j.retrec.2018.08.007

Musselwhite, C., & Haddad, H. (2010). Mobility, accessibility and quality of later life. *Quality in Ageing and Older Adults*, *11*(1), 25–37. https://doi.org/10.5042/qiaoa.2010.0153

National Association of Colleges and Employers (NACE), (accessed 14 March 2023). https://www.naceweb.org/about-us/equity definition/#:~:text=The%20term%20%E2%80%9Cequity%E2%80%9D%20refers%20to,and %20make%20adjustments%20to%20imbalances.

Neutens, T., Schwanen, T., Witlox, F., De Maeyer, P. (2010). Equity of urban service delivery: A comparison of different accessibility measures. *Environ. Plan*. A. 42, 1613–1635. https://doi.org/10.1068/a4230.

Noboru Harata, K. K. (2020). TRANSPORT POLICY IN PERSPECTIVE: 2020. *The Japan Research Center for Transport Policy*, *White paper*.

Nordbakke, S., & Schwanen, T. (2014). Well-being and Mobility: A Theoretical Framework and Literature Review Focusing on Older People. *Mobilities*, *9*(1), 104–129. https://doi.org/10.1080/17450101.2013.784542

OECD. (2013). *OECD Guidelines on Measuring Subjective Well-being*. OECD. https://doi.org/10.1787/9789264191655-en

Olsson, L. E., Gärling, T., Ettema, D., Friman, M., & Fujii, S. (2013). Happiness and Satisfaction with Work Commute. *Social Indicators Research*, *111*(1), 255–263. https://doi.org/10.1007/s11205-012-0003-2

Palm, M., Farber, S., Shalaby, A., & Young, M. (2021). Equity Analysis and New Mobility Technologies: Toward Meaningful Interventions. *Journal of Planning Literature*, *36*(1), 31–45. https://doi.org/10.1177/0885412220955197

Pangbourne, K., Mladenović, M. N., Stead, D., & Milakis, D. (2020). Questioning mobility as a service: Unanticipated implications for society and governance. *Transportation*

Research Part A: Policy and Practice, *131*, 35–49. https://doi.org/10.1016/j.tra.2019.09.033

Pantelaki, E., Maggi, E., & Crotti, D. (2021). Mobility impact and well-being in later life: A multidisciplinary systematic review. *Research in Transportation Economics*, *86*, 100975. https://doi.org/10.1016/j.retrec.2020.100975

Pereira, R. H. M., & Boisjoly, G. (2021). *Social issues in transport planning*.

Pereira, R. H. M., Schwanen, T., & Banister, D. (2017). Distributive justice and equity in transportation. *Transport Reviews*, *37*(2), 170–191. https://doi.org/10.1080/01441647.2016.1257660

Pereira, R. H.M., K., Alex. (2021). *Transportation Equity*. International Encyclopedia of Transportation. Vol. 1,. https://doi.org/10.1016/B978-0-08-102671-7.10053-3

Polis. (2017). *Mobility as a service: Implications for urban and regional transport*. https://www.polisnetwork.eu/uploads/ Modules/PublicDocuments/polis-maas-discussion-paper-2017—final_.pdf.

Polydoropoulou, A., Pagoni, I., & Tsirimpa, A. (2020). Ready for Mobility as a Service? Insights from stakeholders and end-users. *Travel Behaviour and Society*, *21*, 295–306. https://doi.org/10.1016/j.tbs.2018.11.003

Portland, GOV, Transportation Wallet Programs Overview (accessed 10 March 2023).

Pritchard, J.P., Stępniak, M., Geurs, K.T. (2019). Equity analysis of dynamic bike-and-ride accessibility in the Netherlands, in: Lucas, K., Martens, K., Di Ciommo, F., Dupont-Kieffer (Eds.), A., *Measuring Transport Equity,* Elsevier, Amsterdam, 73–83.

Reardon, L., Mahoney, L., & Guo, W. (2019). 13—Applying a subjective well-being lens to transport equity. In K. Lucas, K. Martens, F. D. Ciommo, & A. Dupont-Kieffer (Eds.), *Measuring Transport Equity* (pp. 205–215). Elsevier. https://doi.org/10.1016/B978-0-12-814818-1.00013-5

Rush, K. L., Ouellet, L. L., & Hautman, M. A. (1998). An Analysis of Elderly Clients' Views of Mobility. *Western Journal of Nursing Research*, *20*(3), 295–311. https://doi.org/10.1177/019394599802000303

Ryan, R. M., & Deci, E. L. (2001). On Happiness and Human Potentials: A Review of Research on Hedonic and Eudaimonic Well-Being. *Annual Review of Psychology*, *52*(1), 141–166. https://doi.org/10.1146/annurev.psych.52.1.141

Sakai, K. (2020). Public Transport Promotion and Mobility-as-a-Service. *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences*, *E103.A*(1), 226–230. https://doi.org/10.1587/transfun.2019TSI0001

Saito, T., Kondo, K., Murata, C., Jeong, S., Suzuki, K., Kondo, N. (2015). Gender and regional differences in going-out, social, and leisure activities among older adults. Findings from the JAGES Project. *Japanese Journal of Public Health*. 62, 596–608. https://doi.org/10.11236/jph.62.10_596. PMID: 26607919.

Sánchez, Thomas W., S., Rich, & Ma, Jacinta S. (2003). *MOVING TO EQUITY: Addressing Inequitable Effects of Transportation Policies on Minorities*. Sánchez, Thomas W., Stolz, Rich, and Ma, Jacinta S. (2003). Moving to Equity: Addressing Inequitable Effects of Transportation Policies on Minorities. Cambridge, MA: The Civil Rights Project at Harvard University.

Schikofsky, J., Dannewald, T., & Kowald, M. (2020). Exploring motivational mechanisms behind the intention to adopt mobility as a service (MaaS): Insights from Germany. *Transportation Research Part A: Policy and Practice*, *131*, 296–312. https://doi.org/10.1016/j.tra.2019.09.022

Schwanen, T., & Ziegler, F. (2011). Wellbeing, independence and mobility: An introduction. *Ageing and Society*, *31*(5), 719–733. https://doi.org/10.1017/S0144686X10001467

Sen, A. (1992). Inequality Reexamined, Harvard University Press, *Economics and Philosophy,* 11(1), 182–189. https://doi:10.1017/S026626710000328X.

Shankar, A., McMunn, A., Banks, J., & Steptoe, A. (2011). Loneliness, social isolation, and behavioral and biological health indicators in older adults. *Health Psychology*, *30*(4), 377–385. https://doi.org/10.1037/a0022826

Shankar, A., Mcmunn, A., Banks, J., & Steptoe, A. (2011). Loneliness, Social Isolation, and Behavioral and Biological Health Indicators in Older Adults. *Health Psychology : Official Journal of the Division of Health Psychology, American Psychological Association*, *30*, 377–385. https://doi.org/10.1037/a0022826

Shared-Use Mobility Center. (2020). *Towards the Promise of Mobility as a Service (MaaS) in the U.S.*

Sharifi, F., Levin, I., M.Stone, W., & Nygaard, A. (2021). Green space and subjective well-being in the Just City: A scoping review. *Environmental Science & Policy*, *120*, 118–126. https://doi.org/10.1016/j.envsci.2021.03.008

Shirgaokar, M. (2020). Expanding Seniors' Mobility through Phone Apps: Potential Responses from the Private and Public Sectors. *Journal of Planning Education and Research*, *40*(4), 405–415. https://doi.org/10.1177/0739456X18769133

Smith, G., & Hensher, D. A. (2020). Towards a framework for Mobility-as-a-Service policies. *Transport Policy*, *89*, 54–65. https://doi.org/10.1016/j.tranpol.2020.02.004

Smith, G., Sochor, J., & Sarasini, S. (2018). Mobility as a service: Comparing developments in Sweden and Finland. *Research in Transportation Business & Management*, *27*, 36–45. https://doi.org/10.1016/j.rtbm.2018.09.004

Sochor, J., Arby, H., Karlsson, I. C. M., & Sarasini, S. (2018). A topological approach to Mobility as a Service: A proposed tool for understanding requirements and effects,

and for aiding the integration of societal goals. *Research in Transportation Business & Management*, *27*, 3–14. https://doi.org/10.1016/j.rtbm.2018.12.003

Social Exclusion Unit (2003). Making the connections: Final report on transport and social exclusion, Office of the Deputy Prime Minister, Available from: www.socialexclusionunit.gov.uk

Sugita, S. (2008). Kaimono nanmin. Mō hitotsu no kōreisha mondai 買物難民 もうひとつの高齢者問題 (Far Way From Shopping, Another Problem for the Elderly People), Ōtsuki Shoten, Tokyo.

Stanley, J., Hensher, D. A., Stanley, J., Currie, G., Greene, W. H., & Vella-Brodrick, D. (n.d.). Social Exclusion and the Value of Mobility. *Journal of Transport Economics and Policy*, *45*, 27.

Stanley, J., Hensher, D. A., Stanley, J., Currie, G., Greene, W. H., & Vella-Brodrick, D. (2011). Social Exclusion and the Value of Mobility. *Journal of Transport Economics and Policy*, *45*, 27.

Stanley, J. K., Hensher, D. A., Stanley, J. R., & Vella-Brodrick, D. (2011). Mobility, social exclusion and well-being: Exploring the links. *Transportation Research Part A: Policy and Practice*, *45*(8), 789–801. https://doi.org/10.1016/j.tra.2011.06.007

Steptoe, A., Shankar, A., Demakakos, P., & Wardle, J. (2013). Social isolation, loneliness, and all-cause mortality in older men and women. *Proceedings of the National Academy of Sciences*, *110*(15), 5797–5801. https://doi.org/10.1073/pnas.1219686110

Stiglitz, J., Sen, A., & Fitoussi, J. (2009). *Report of the Commission on the Measurement of Economic Performance and Social Progress (CMEPSP)*.

Susan Shaheen, C. B., & Adam Cohen, B. Y. (2017). *Travel Behavior: Shared Mobility and Transportation Equity*.

The World Economic Forum, Transforming rural mobility in Japan and the world. https://www.weforum.org/whitepapers/transforming-rural-mobility-in-japan-and-the-world, 2020 (accessed 14 May 2021).

Thomas, D. N., Heer, N., Mitchell, I. W., Karner, A., Levine, K., Shuster, J., Ma, K., Transit Cooperative Research Program, Transportation Research Board, & National Academies of Sciences, Engineering, and Medicine. (2022). *Racial Equity, Black America, and Public Transportation, Volume 1: A Review of Economic, Health, and Social Impacts* (p. 26710). Transportation Research Board. https://doi.org/10.17226/26710

Todd Litman. (2021). *Introduction to Multi-Modal Transportation Planning*. Victoria Transport Policy Institute.

Transit Center, CNT. (2021). *Equity in Practice: A Guidebook for Transit Agencies*. 97.

Utsunomiya, K. (2016). Social capital and local public transportation in Japan. *Research in Transportation Economics*, *59*, 434–440. https://doi.org/10.1016/j.retrec.2016.02.001

Vecchio, G., Tiznado-Aitken, I., Hurtubia, R. (2020). Transport and equity in Latin America: A critical review of socially oriented accessibility assessments. *Transp. Rev*. 40, 354–381. https://doi.org/10.1080/01441647.2020.1711828.

Wang, C., Quddus, M., Enoch, M., Ryley, T., & Davison, L. (2014). Multilevel modelling of Demand Responsive Transport (DRT) trips in Greater Manchester based on area-wide socio-economic data. *Transportation*, *41*(3), 589–610. https://doi.org/10.1007/s11116-013-9506-1

Wang, Y., Cao, M., Liu, Y., Ye, R., Gao, X., & Ma, L. (2022). Public transport equity in Shenyang: Using structural equation modelling. *Research in Transportation Business & Management*, *42*, 100555. https://doi.org/10.1016/j.rtbm.2020.100555

World Health Organization (WHO). (2007). Ageing and Life Course: Towards an Age friendly World. http://www.who.int/ageing/age-friendlyworld/en/

Williams, K., & Golub, A. (2017). *Evaluating the Distributional Effects of Regional Transportation Plans and Projects*. Portland State University. https://doi.org/10.15760/trec.175

Yang, Y., Sasaki, K., Cheng, L., Liu, Xingwei. (2022). Gender Differences in Active Travel among Older Adults: Non-Linear Built Environment Insights, Transportation Research Part D: Transport and Environment, 110, 103405. https://doi.org/10.1016/j.trd.2022.103405.

Yeganeh, A.J., Hall, R., Pearce, A., Hankey, S. (2018). A social equity analysis of the U.S. public transportation system based on job accessibility. *J. Transp. Land Use*. 11, 1039–1056. https://doi.org/10.5198/jtlu.2018.1370.

Yingling Fan, A. G., & Gina Baas, L. V. D. (2019). Advancing Transportation Equity: Research and Practice. *Center for Transportation Studies, University of Minnesota. Retrieved from the University of Minnesota Digital Conservancy*, 81.

Ziegler, F., & Schwanen, T. (2011). 'I like to go out to be energised by different people': An exploratory analysis of mobility and wellbeing in later life. *Ageing and Society*, *31*(5), 758–781. https://doi.org/10.1017/S0144686X10000498

Zijlstra, T., Durand, A., Hoogendoorn-Lanser, S., & Harms, L. (2019). *Promising Groups for Mobility-as-a-Service in the Netherlands*.

Research publications

1. Tugsdelger Chinbat, Nakamura Fumihiko, Matsuyuki Mihoko, Tanaka Shinji, Ariyoshi Ryo, Impact assessment study of mobility-as-a-service (MaaS) on social equity through nonwork accessibility in rural Japan, Asian Transport Studies, Volume 9, 2023, 100109, ISSN 2185-5560, https://doi.org/10.1016/j.eastsj.2023.100109.
2. Tugsdelger Chinbat, Nakamura Fumihiko, Matsuyuki Mihoko, Tanaka Shinji, Kanda Yusuke, How Mobility Affects the Well-Being of Older People in Rural Japan through a Social Equity Framework, TRANSED Conference, TRB, 2022, TRR journal under revision
3. Tugsdelger Chinbat, Nakamura Fumihiko, Matsuyuki Mihoko, Tanaka Shinji, Abe Ryosuke, Development and implementation of equity: implication for Mobility-as-a-Service in Japan, WCTR- Canada conference 2023, WCTR journal under revision

Appendix I

Person trip-survey in Shobara (developed by NITAS, MLIT, 2019)

Socio-economic indicators

Sex

Age

Please select your residence below.

Postal code

Address

Code	Question	Answer
Q1S1.1 -12	How often do you go out each of the following purposes? 1. Work 2. Education 3. Shopping (groceries) 4. Shopping (home appliances) 5. restaurant 6. Hospital 7. Administrative procedure 8. Bank 9. Exercise 10. Meeting 11. Movie 12. Pachinko	1_every day 2_5-6 times a week 3_ 4-3 times a week 4_ 1 or 2 times a week 5_about once every fortnight 6_less than about once a month 7_None
Q1S2.1 -24	What is the most frequently used means of transportation when you go out? a. Most frequently used means of transportation (only one) b. Items other than the above (any number)	1_Car 2_Car rental/car share 3_Transportation for family/friends 4_Railway 5_Bus 6_Bus on Demand 7_Taxi

		8_Walking/Biking 9_Other 10_I don't use any other means
Q1.S3.1 -12	Please answer the amount of consumption (other than transportation expenses) when moving for the following purpose in November. 1. work 2. Education 3. Shopping (groceries) 4. Shopping (home appliances) 5. restaurant 6. hospital 7. Administrative procedure 8. Bank 9. Exercise 10. Meeting 11. Movie 12. Pachinko	1_0 yen 2_to less than about 500 yen 3_ 500 yen - 1,000 yen 4_ 1,000 - 1,500 yen 6_ 2,000 - 3,000 yen 7_ 3,000 - 4,000 yen 8_ 4,000 - 5,000 yen 9_ 5,000 - 7,500 yen 10_ 7,500 - 10,000 yen 11_ 10,000 yen or more 12_Not carrying out any travel for that purpose"
Q1.S5.1	Imagine you travel by public transport from your home to the place you usually go to. Distance of the nearest bus stop.	By /m/
Q1.S6.1-	Travel time by public transport	By /min/
Q1S7.1	Travel cost by public transport	By /yen/
Q1S8.1	Travel time by private car	By /min/
Q4S1	How often do you use public transportation in a week?	1_every day 2_5-6 times a week 3_ 4-3 times a week 4_ 1 or 2 times a week 5_about once every fortnight 6_less than about once a month 7_None
Q4S2	Do people close to you, such as family members and acquaintances, use public transportation?	"1_Family members are using this service

		2_A close acquaintance of mine uses it 3_Family and acquaintances both use it 4_No one uses it 5_I don't know."
Q4S3	Please tell me the car you can use and whether you have a license.	_I have a licence and a car that I can use 2_I have a license but no car available 3_No licence and no car"
Q4S4	Please tell me how often you drive a car.	1_every day 2_5-6 times a week 3_ 4-3 times a week 4_ 1 or 2 times a week 5_about once every fortnight 6_less than about once a month 7_None
Q4S5.1	Please tell us if you have any concerns or concerns about movement. 1. Are you worried about your driving?	1_very much 2_fairly 3_Neither 4_not so much 5_Not at all
Q4S5.2	2. Do you have a family who is worried about driving a car? "	
Q4S5.3	3. Are you worried about moving at night (safety, crime, etc.) "	
Q4S5.4	4. After 10 years, are you worried about moving in your daily life? "	
Q4S6	Family living situation	1_Spouse 2_Children 3_Mother/Father 4_Grandfather/Grandmother 5_Other Not present (living alone)
Q4S7	Please tell me your occupation	1_Employee, civil servant

		2_Self-employed 3_Student 4_Housewife 5_Unemployed 6_Other

Request for cooperation in responding to the questionnaire regarding the Tojo area MaaS (reservation-type) demonstration experiment.

Thank you very much for your cooperation with the Tojo area MaaS (reservation-type). Through this demonstration experiment, we will deepen our consideration of transportation services that are easier to use. We apologize for the inconvenience, but we appreciate your cooperation in filling out this questionnaire.
(Please return it by the enclosed reply envelope by February 18th)

Tojo Area MaaS Demonstration Operation Council

Question 1: Please answer about yourself.

Sex	□ Male □ Female
Age	□ Below 20 □ 30 □ 40 □ 50 □ 60 □ 70 □ 80 □ Above 90
Family structure	□ Alone □ with partner □ with parents □ with kids □ with parents and kids □ others ( )
Address	Postal code （〒 — ）
Occupations	□ Company employee / public employee □ Agriculture □ Self-employed □ Full-time housewife □ Student □ Part-time □ Unemployed □ Other ( )
Do you have a mobile phone, etc.?	□ I have a smartphone □ I have a mobile phone (not a smartphone) □ I have a tablet □ I don't have any

Question 2: About frequency of traditional bus usage and number of going out

How often have you used the fixed-route bus so far?	□ Almost every day □ 2-3 times a week □ About once a week □ About once a month □ About once every two to three months. □ Not at all
How often have you used public taxis so far?	□ Almost every day □ 2-3 times a week □ About once a week □ About once a month □ About once every two to three months. □ Not at all
What is the means of transportation for going out in your daily life?	□ Bus □ Taxi □ Municipal taxi □ Drive by yourself □ Riding in a car driven by a family member □ Riding in a car driven by an acquaintance other than family members □ Motorbike/Bicycle □ Other ( )

Question 3: How far is it to the nearest "traditional bus" and "reserved bus/taxi" stops from your home?

Reservation bus/taxi bus stop on foot	On foot _____ Minutes
Bus stop for traditional bus (For Taishaku and Tojo districts only)	On foot _____ Minutes

Question 4: Regarding the frequency of traditional bus usage and number of going out during the demonstration experiment period

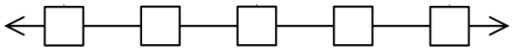
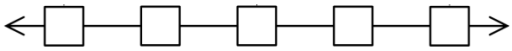
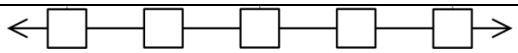
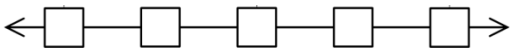
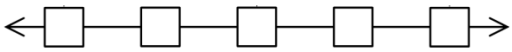
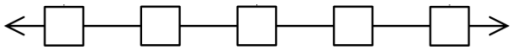
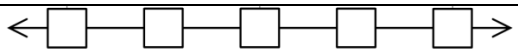
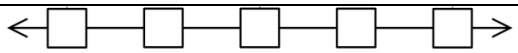
How many times did you use demand-responsive transportation during the experiment?	One way: 1 time, Round trip: 2 times times
How many times did you use the fixed-route bus during the experiment?	One way: 1 time, Round trip: 2 times times

↓ Below, only those who used during the period
Please answer. (If you are not using it, go to Question 6.)

What was the purpose of going out by demand-responsive transportation or fixed-route bus during this experiment?	□ Shopping □ Walking/Exercise □ Hospital visits □ Entertainment/leisure □ Work □ Visiting acquaintances □ Other ( )
Where often do you go to using bus?	
Did you go out more often than usual during the experiment?	□ Significantly increased □ Slightly increased □ Neither □ Decreased

Question 5: About "reserved buses/taxi" and "unlimited ride system"

(1) Please tell us your experience of using the reserved bus or taxi.

	I think so Neither I don't think so
Reservation buses and taxis are convenient because you can get on and off near your house	
The date and time of operation of the reserved bus/taxi matched the day and time when I wanted to go out.	
Reservation bus/taxi reservation is complicated.	
I'm worried because the arrival time of the reserved bus or taxi may change at the bus stop	
Reservation buses and taxis that run close to home are convenient for carrying things you bought at your destination	
If you use reserved buses or taxis, it is likely that the number of outings using public transportation will increase	
If it is an unlimited ride fare, I think I will go out more and more.	
It was good to get bonus points for "Horoka" when you get on a reserved bus or taxi	

Question 6: If there are public transportation services such as the following buses, would you like to use them?

Like a fixed-route bus, you can get on the bus from a designated bus stop without making a reservation, and if you make a reservation in advance, you can get on and off at any place other than the bus stop, such as in the center of the town or near your home.	□ I think I will use it □ I think I will use it sometimes. □ I don't think I will use it □ I don't know
A reservation-based bus / taxi that will pick you up at a cram school, hot spring, or near your home after meals late at night.	□ I think I will use it □ I think I will use it sometimes. □ I don't think I will use it □ I don't know

Question 7: How often do you go out to the center of Tojo Town in a month?

	In total	By bus	Someone picked up
Shopping			
Outpatient / rehabilitation			
Entertainment (hot springs, eating out, etc.)			

Meeting friends/people			
Going out with family			
Exercise (walking, ground golf, etc.)			
Participate in local events such as neighborhood associations			

Question 8: About daily movement

How do you go out for shopping?	□ Go shopping when you want to □ I try to go shopping when I have other errands such as going to the hospital. □ I try to buy in bulk as much as possible and reduce the number of times I go out.
Do you usually go out when you want to go out?	□ I can go out when I want to go out □ I want to go out, but I refrain to go out ↓ Please tell me the reason why you refrain to go out □ There is no bus or other service at the time you want to go out □ Bus fare is high □ Taxi fare is high □ It is far from the bus stop □ It is difficult to carry luggage such as what you bought □ I have a place I want to go, but I have no means of transportation □ I am worried about the burden on those who send it to my family etc. □ Others () □ I don't want to go out too much □ There are few places and events you want to go to □ It is troublesome to go out. □ There is no particular reason □ Others ( )
If you can move relatively freely by bus at the time you want to move, what kind of out of home activities do you think will increase?	[Check all that apply] □ Shopping □ Eating out □ Onsen □ Exercise □ Visiting and meeting with friends and acquaintances □ Other ( )

Request for cooperation in responding to the questionnaire regarding the public transportation.

Thank you very much for your cooperation with the Tojo area MaaS (reservation-type). Through this demonstration experiment, we will deepen our consideration of transportation services that are easier to use. We apologize for the inconvenience, but we appreciate your cooperation in filling out this questionnaire.
(Please return it by the enclosed reply envelope by February 24th)

Tojo Area MaaS Demonstration Operation Council

Question 1: Please answer about yourself.

Sex	□ Male □ Female
Age	□ Below 20 □ 30 □ 40 □ 50 □ 60 □ 70 □ 80 □ Above 90
Family structure	□ Alone □ with partner □ with parents □ with kids □ with parents and kids □ others ( )
Address	Postal code （〒 — ）
Occupations	□ Company employee / public employee □ Agriculture □ Self-employed □ Full-time housewife □ Student □ Part-time □ Unemployed □ Other ( )
Do you have a mobile phone, etc.?	□ I have a smartphone □ I have a mobile phone (not a smartphone) □ I have a tablet □ I don't have any
What is the means of transportation in your everyday life? (all that apply)	□ Bus □ Taxi □ Municipal taxi □ Drive by yourself □ Riding in a car driven by a family member □ Riding in a car driven by an acquaintance other than family members □ Motorbike/Bicycle □ Other ( )

Question 2: Tell me about your car and driver's license status.

Do you own a car?	□ Yes, I will drive myself □ Yes, but I will not drive □ No
Do you have a driver's license?	□ Yes □ I have never owned □ I had it but returned it
[Those who answered that they have a license] Thinking of returning your driver's license?	□I don't plan on returning it □ I am thinking of returning it before the next license renewal. □ I have not decided, but I am thinking of returning it.
Which of the services on the right do you think	□ Maintenance of the current bus □ Increase the number of current buses

would make it easier to return your license? **[All that apply]**	□ Reservation bus / taxi that will come to your house □ Reserved buses and taxis that operate late at night □ Mobile sales service for daily necessities □ Telemedicine service □ Life support services (help with daily life such as changing light bulbs) □ No matter what kind of service you have, you can't let go of your own car. →Reason ( )

Question 3: Regarding the usage status of buses and taxis

How often have you used the fixed-route bus so far?	□ Almost every day □ 2-3 times a week □ About once a week □ About once a month □ About once every two to three months. □ Not at all
How often have you used public taxis so far?	□ Almost every day □ 2-3 times a week □ About once a week □ About once a month □ About once every two to three months. □ Not at all
Reasons People Rarely Used Regular Buses and Community-Sharing Taxis	□ No need for use given private car □ Unable to drive but picked up by family □ High fare □ Regular bus and community-sharing taxi unavailable at desired time □ Community-sharing taxi unavailable on desired day □ Difficulty in reserving community-sharing taxi □ Distance of bus stop □ Unfamiliarity with local buses and taxis □ No particular reason □ Other ( )
Please tell us about the facilities in Tojo town that you think would be good to go by bus or taxi [Multiple answers are possible]	

If you have any ideas or opinions on how to make traditional buses or community taxis more convenient, please feel free to write them.	

Question 4: Regarding travel with family and acquaintances

Do family members and acquaintances drive, pick up and move around for daily necessities?	□ Almost every day □ 2-3 times a week □ About once a week □ About once a month □ About once every two to three months
Do you find it burdensome to drive, pick up and move for your family and acquaintances?	□ I feel very burdensome □ I feel a little bit □ Neither □ I don't feel it very much □ I don’t feel so

Question 5: Regarding the demonstration experiment of Tojo MaaS

Did you use the reserved bus / taxi during the demonstration experiment?	□ Used □ I tried to use it, but I couldn't. ↓Please tell me the reason [all that apply] □ It was inconvenient □ I didn't know how to use it □ I thought about using it, but felt it was troublesome. □ Other ( ) □ Did not use ↓Please tell me the reason [all that apply] □ No need to use buses or taxis □ The time zone to use does not match □ I thought about using it, but felt it was troublesome. □ Other ( )

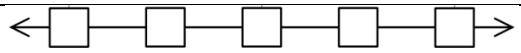
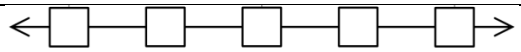
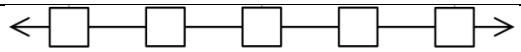
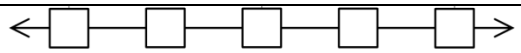
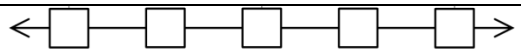
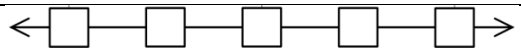
Question 8: About participation in local activities

Do you participate in local activities, events, and sports (ground golf, etc.)?	□ I often participate □ I sometimes participate □ not so much/ can not

Question 9: Do you need assistance such as pick-up and drop-off for moving around freely in your daily life?

Shopping	□ Required □ Sometimes required □ Not required
Eating out	□ Required □ Sometimes required □ Not required
Exercise	□ Required □ Sometimes required □ Not required
Visiting friends and family	□ Required □ Sometimes required □ Not required
Participation in community activities and events	□ Required □ Sometimes required □ Not required

Question 10: Your satisfaction in daily life

	Very satisfied Neither Very dissatisfied
Shopping in everyday life	
Eating out	
Exercise in daily life	
Visiting and meeting friends and acquaintances	
Participation in community activities and events	
Overall satisfaction in life today	

Appendix II

September 2, 2022

Yokohama National University Transportation and City Laboratory

Doctorate candidate Tugsdelger

Interview on MaeMaaS initiatives in Maebashi City

We would like to express our sincere gratitude to your agency for your deep understanding of our university. We would like to hear about MaeMaaS initiatives at your organization and we appreciate your kind cooperation.

Interview detail:

- Date: September 15, 2022 15:00-16:00
- Location: Maebashi City Hall
- Expected attendees:
  - Chinbat Tugsdelger (Questioner: Yokohama National University Transportation and City Research Laboratory Doctoral Course)
  - Tomoo Chiba (questioner, undergraduate student, Transportation and City Research Laboratory, Yokohama National University)
  - Gen Hayauchi (Attendant, Researcher, Institute of Innovation for Future Society, Nagoya University / Part-time faculty, Yokohama National University)

- Content:

Our laboratory is conducting research on institutional organization of MaaS projects and their focus on social equity impacts in the existing transport plans of local authorities in Japan. Based on our research, we have confirmed that your organization has successfully implemented MaaS project under the “Government’s Smart Mobility Challenge”.

We would be grateful if you could tell us the general authority, roles, regulation, funding, and how you take account equity perspectives when you plan and evaluate the project in the transport policy of your organization. The information you are requested to provide is listed on the next page.

- Contact:

Yokohama National University, Graduate School of Urban Innovation, Transportation and City Laboratory
2nd year doctoral student, Chinbat Tugsdelger
Location: 79-5 Tokiwadai, Hodogaya-ku, Yokohama 240-8501 Civil Engineering Building Transportation and City Research
Email: chinbat-tugsdelger-dt@ynu.jp / Telephone: 080-3247-4147

1. **Authority and roles**

1.1. Does central government facilitate knowledge transfer activities about lessons learned and best practices from pilot evaluations among various local transport bodies?

1.2. Could you explain your role that promotes MaaS in your local area?

2. **Regulation/Legislation**

2.1 What kind of difficulties do you face in order to follow the rules and regulation from the central government?

2.2 What data sharing requirements do you have?

3. **Funding**

3.1 Did you face any difficulties during the application system of grant funding in terms of acceptance timeline, application procedure etc?

3.2 Do you have any subsidy/financial support system for MaaS operation? If yes, could you please explain it in detail. (Whether it goes to support the business model of MaaS or toward grants to help start untested ideas)

1. As a technical verification of MaaS

(1) Not applicable at all (2) Not very applicable (3) Neither

(4) Somewhat applicable (5) Very applicable

2. As a verification of the MaaS business model

(1) Not applicable at all (2) Not very applicable (3) Neither

(4) Somewhat applicable (5) Very applicable

3. As a verification of changes in behavior, etc. due to MaaS

(1) Not applicable at all (2) Not very applicable (3) Neither

(4) Somewhat applicable (5) Very applicable

4. **Equity perspective**

4.1. Do you have a system in place to measure social equity benefits when assessing transport?

4.2. Do you face equity issues related to specific geographies or regions? If yes, in what ways do you address geographical equity?

4.3. Please tell us if you are doing anything related to citizen participation to revitalize public engagement. For example: cooperation and collaboration with local companies and NPOs etc.

4.4. In the Japanese version of the MaaS promotion and support project in 2022, social acceptance was listed as one of the vital points. Would you please explain more about social acceptability including handling and verification methods.

4.5. Are there any initiatives to change modal shift?

4.6. Do you have any ideas or initiatives to support accessibility to the train station by private car, bicycle, or bus?

4.7. Do you take any initiatives to improve the accessibility of MaeMaaS?

4.8. Could you tell us ask about the situation and response regarding digital barriers related to MaeMaaS?

4.9. About MaeMaaS for vulnerable groups. For example.

4.9.1. What have you done so far for the social participation of people in wheelchairs?

4.9.2. What have you done so far for the social participation of older people?

4.9.3. What have you done so far for the blind and visually impaired to participate in society?

September 15, 2022

Yokohama National University Transportation and City Laboratory

Doctorate candidate Tugsdelger

Interview on Shizuoka MaaS initiatives in Shizuoka City

We would like to express our sincere gratitude to your agency for your deep understanding of our university. We would like to hear about MaeMaaS initiatives at your organization and we appreciate your kind cooperation.

Interview detail:

- Date: September 20, 2022 10:00-11:00
- Location: Onlien (Teams)
- Expected attendees:
  - Chinbat Tugsdelger (Questioner: Yokohama National University Transportation and City Research Laboratory Doctoral Course)
  - Gen Hayauchi (Attendant, Researcher, Institute of Innovation for Future Society, Nagoya University / Part-time faculty, Yokohama National University)

- Request

Our laboratory is conducting research on institutional organization of MaaS projects and their focus on social equity impacts in the existing transport plans of local authorities in Japan. Therefore, we would like to hear about their efforts, particularly from the perspective of social equity in the project. The details of the information we would like to know are listed on the following page.

- Contact:

Yokohama National University, Graduate School of Urban Innovation, Transportation and City Laboratory
2nd year doctoral student, Chinbat Tugsdelger
Location: 79-5 Tokiwadai, Hodogaya-ku, Yokohama 240-8501 Civil Engineering Building Transportation and City Research
Email: chinbat-tugsdelger-dt@ynu.jp / Telephone: 080-3247-4147

[Note]
Social equity in this interview: Social equity in transportation means that everyone, including person with disabilities and the elderly, can access public transportation from various perspectives such as financial and physical accessibility point.

1. Do you have a system in place to measure social equity benefits when assessing transport?
2. We have found from “FY2021 Shizuoka MaaS core business demonstration experiment" that there are efforts to secure transportation and create opportunities for the elderly to go out for out-of-home activities. Could you please tell us if Shizuoka MaaS is working on citizen participation to revitalize public engagement. For example: cooperation and collaboration with local companies and NPOs etc.
3. Could you tell us ask about the situation and response regarding digital barriers related to MaeMaaS?
4. Are there any initiatives to change modal shift?
5. Do you have any ideas or initiatives to support accessibility to the train station by private car, bicycle, or bus?
6. Do you take any initiatives to improve the accessibility of MaeMaaS?
7. About MaeMaaS for vulnerable groups. For example.
    7.1. What have you done so far for the social participation of people in wheelchairs?
    7.2. What have you done so far for the social participation of older people?
    7.3. What have you done so far for the blind and visually impaired to participate in society?