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Three Essays on Foreign Direct Investment and Distribution of Economic Activity

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**Doctoral Dissertation**

# Three Essays on Foreign Direct Investment and Distribution of Economic Activity


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# CHAPTER 1

# ABSORPTIVE CAPACITY AND FOREIGN DIRECT INVESTMENT SPILLOVER EFFECTS: THE CASE OF VIETNAM[1]


## Abstract

Many developing countries attract FDI with the hope that this capital will increase the productivity of domestic firms and improves the local manufacturing industries. At the same time, a lot of papers investigate the impact of FDI inflows on the performance of local firms in developing countries such as China, Mexico, Venezuela, Romania, and Lithuania using Cobb-Douglas production functions with the significant role of FDI intra and inter industries linkages and show mixed results. Why did these different results happen? This paper deals with Foreign Direct Investment inflows impact on domestic firms' productivity through horizontal and vertical linkages and the factors that affect this relationship with panel data at the firm-level of manufacturing industry in Vietnam from 2004 to 2010 is used. The research finds that forward and backward linkages of FDI firms with local enterprises increase the productivity of domestic firms but the horizontal linkage only has a positive impact on these firms if the neighbor countries also attract FDI in the same industries. Otherwise, this impact is negative. Absorptive capacity of local firms also impacts on their performance by non-linear relationship.



**Keywords:** Foreign Direct Investment, spillover effect, absorptive capacity, IV, non-linear



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## 1. Introduction

Spillover effects of FDI at developing countries are concerned by many policy makers and researchers recently because of the important role of FDI in these economies. Much of the research tries to point out the impact of this capital through the linkages between foreign affiliates and domestic partners as well as domestic competitors, and presence of foreign ownership in the local enterprises, and other factors which may impact the strength of this relationship such as the absorptive capacity of domestic firms. Using Vietnamese firm-level data to examine spillover effects of FDI, this paper has following contributions: (i) the new measurement of absorptive capacity of firm is introduced; (ii) non-linear relationship between absorptive capacity and firm's productivity along with OLS method is found; (iii) an instrument variable method is utilized that takes Thailand's FDI indicators into consideration of the spillover effect.

Foreign Direct Investment (FDI) inflows became an important source of capital for the Vietnamese economy from the start of "Doi Moi" reforms in 1988 that is characterized by the increase of quality and quantity of new products, high technology, jobs and financial markets. At the same time, FDI changes the performance of Vietnamese domestic firms. The government raises the concern about whether FDI enterprises have a positive or negative impact on the productivity and existences of domestic firms in inter-industry and intra-industry. The reality shows both scenarios.

Research of the economics spillover effects of FDI inflows on the developing countries is getting more attentions of economists recently. FDI spillovers take place when the productivity of the local firm's increases due to entry or presence of transnational corporations (TNCs). In horizontal linkages, domestic firms can mimic technology from TNCs, or compete with TNCs by using the existing technology and resources more efficiently or create new tech (Blomström & Kokko, 1998). In vertical linkages, they try to develop their production

standards to engage in the global value chain with the TNCs from upstream or downstream sectors. To measure the FDI spillover effects, economists apply a variety of ways such as the availability of foreign equity in the firm (Aitken & Harrison, 1999), the share of foreign gross output within industry as horizontal linkages effect (Sjöholm, 1999), and the contracts between TNCs and their local suppliers/distributors as vertical linkage effects (Javorcik, 2004). While existing firm-level studies on Venezuela, Bulgaria, Poland, Lithuania, and Romania fail to find the significant effect or negative impact of the TNCs on domestic firms in the same sector, a case study by Anwar and Nguyen (2014) on Vietnam finds mixed results depending on the host investors of FDI.

Beside linkages and presence of FDI enterprises, other determinants such as absorptive capacity or technology gap, geography and other methodology such as non-linear regression, instrument variable are investigated to explain the spillover of foreign affiliates. However, all of the research has not explained well about the FDI spillovers. Measurement of absorptive capacity is not sufficient, non-linear regression of absorptive capacity has not found the consistent results or the instruments also present the different outcomes. What should be better absorptive capacity variable? Does it have a non-linear relationship with the domestic productivity? If absorptive capacity has heterogeneity problem, should another methodology like IV to measure spillover effect be better? Which are the best IV proxies?

This study has three purposes. First, it examines whether the presence of multinationals in intra-industry and inter-industry pushes the productivity of domestic firms. Second, this paper provides new measurement of absorptive capacity to test its impact on the productivity. Third, this research applies non-linear regression and IV to test the relationship between absorptive capacity and productivity of domestic firms as well as the impact of FDI inflows into Thailand on the productivity of firms in Vietnam.

The analysis is based on three datasets. The first is from the Annual Enterprises Survey conducted by General Statistics Office of Vietnam (GSO). The survey covers all firms in Vietnam. The data constitutes a strong balanced panel covering the period 2004-2010 of manufacturing industry. The second is from Vietnamese input-output table 2007 also conducted by GSO where there are 138 industries for the whole economy. After merging these two datasets, the dataset includes 48 industries in manufacturing sector. The third dataset is the statistics of FDI inflows to Thailand that is made by The Board of Investment of Thailand (BOI). Focusing on developing country such as Vietnam to measure the FDI spillover effect is suitable for this project because the top investors in Vietnam are developed economies such as Japan, Singapore, Hong Kong, Taiwan etc. bringing skilled labors and high technology into Vietnam then makes Vietnam a good place for productivity spillovers.

The results of this study can be summarized as follow. The empirical results are consistent with previous research that is the significant positive relationship of backward linkage of FDI and productivity of domestic firms. The forward linkage also has a positive relationship with the performance of domestic firms, this result is robust and bigger than the backward linkage. The horizontal linkage has mix signs. There is a positive horizontal relationship of foreign capital with the output of Vietnamese firms only if Thailand attracts FDI inflows in the same industry. Otherwise, the presence of FDI enterprises as competitors of domestic firms is not welcomed by local players.

The structure of this research is as follows: Section 2 gives a brief literature overview of FDI spillover channels and the role of absorptive capacity and methods used in spillover effect models. Section 3 discusses FDI inflows into Vietnam, data descriptions. Section 4 is estimation strategy. The results are presented in Section 5 and Section 6 is conclusions.

## 2. Literature review

As this paper links absorptive capacity of domestic firms and FDI spillover effect as well as some methodologies to solve endogeneity problems, this section briefly reviews absorptive capacity and methodologies of this strand of research.

FDI spillover effects are investigated in much of previous research. Spillover effects take place when the appearance of FDI inflows has a positive impact on the productivity, export etc… of the domestic firms through 2 channels: horizontal and vertical linkage with domestic firms (intra-industry and inter-industry). The existence of FDI may have different impacts on the domestic firms' performance that depending on many factors.

In horizontal linkage, the domestic firms most likely benefit from foreign affiliates by four channels. First, they imitate the new production or management procession of them. Second, they acquire the skilled-labor from TNCs. Third, they improve their productivity during competition under the pressure of TNCs on local rivals by using existing technology more efficiently. The last is the domestics firms can learn from the foreign affiliates how to enter the foreign market because FDI enterprises already have these experiences (Görg & Greenaway, 2004).

The reason that multinational corporations access foreign markets through FDI rather than export or license is they have their ownership advantages and they want to internalize certain transactions to protect their technology. How the firms in the host country can absorb their proprietary knowledge through imitation, skills acquisition, completion or export depends on their absorptive capacity that is measured by technology gap (Kokko, 1994) (Girma, 2005) or depends on geography proximity (Aitken & Harrison, 1999). As suggested in theory of Findlay (1978), the greater the distance of development level of two economies, the greater the speed of uptake new technology. However, Glass and Saggi (1998) model presents that

the longer the technological distance between the host and home country, the less likely the host country can absorb the technology from the home country.

Kokko (1994) measures technology gap by the ratio of value added per employee in foreign plants to value added per employee in private locally owned plants in each industry. The result of this research shows that only technology gap does not seem to make spillovers, but both large productivity gaps and large foreign market make the host country difficult to get the spillovers because the foreign affiliates crowd out local competitors from important segments of the market.

Girma has done a series of FDI spillover effect research. In 2005, Girma mentioned about the absorptive capacity and FDI spillover effect using threshold regression techniques. He has done the research in the manufacturing industry at firm-level data from the UK over the period 1989-1999. The absorptive capacity is measured by the distance of the firm from the technology frontiers intra-industry. He found that there are spillover effects. However, this marginal effect is smaller for firms with higher technological capacity and seems to have got the minimum absorptive capacity threshold from which the FDI spillover effects is not positive. The idea of current research is similar with Girma that the spillover effect of FDI has got the minimum absorptive capacity threshold. The way to measure absorptive capacity differentiates this research from previous papers in this field.

While the positive impact of spillover effect through horizontal linkage is not significant, many researchers can find the positive impact of FDI on domestic firm through vertical linkages. When the FDI enterprises choose domestic firms as their suppliers for input and distributors for output, these linkages help local firms to upgrade quality of intermediate products to catch up TNCs' standards and improve technology in consequence, as well as provide sufficient guideline for the customers to use their product effectively (Görg & Greenaway, 2004). Research of (Javorcik, 2004) is well-known by demonstration of positive

backward linkage spillover effect from FDI firm to domestic firm. This vertical linkage is measured at industry level because of the limitation of available data at firm-level. This paper follows the approach of Javorcik to measure vertical linkages between FDI and domestic firms.

The reasons for mixed results of FDI spillover effects are not only technology gap, geography proximity, or development level of the host and home countries, but also the method used in these researches are not always sufficient. In the case that regression may has an endogenous problem, some authors use instrument variable to solve that problem as following research does.

Suggesting that the OLS estimation for FDI spillover effects using cross-sectional data has an endogenous problem with Hausman specification test, Jordaan (2011) has introduced an original instrument for measuring the general FDI intensity of manufacturing industries in Mexico. In addition, he found robust evidence of significantly larger positive FDI spillover effects by IV estimation than OLS method. The instrument variable he uses meets two criteria: uncorrelated with the error term of OLS function, and sufficiently correlates with the variable FOR. FOR stands for the presence of intra-industry FDI spillovers which is measured by employment share of foreign-owned firms within each industry. Variable named US is used as a proxy of FDI intensity which is measured by the ratio of employees working in foreign-owned firms over the total number of industry employees in US industries. The second instrument is US-VA which is average value added for US manufacturing industries for the period 1988-1995. Results of this research show that FDI inflows move toward the low productivity industry and the IV methods show more complex tendency from FDI flows that maybe OLS both underestimate or overestimate the FDI spillovers. Considering the case of Vietnam, the current paper uses Thailands FDI inflows characteristic as IV variables. These

IV variables have not yet examined in any previous paper about FDI spillover effect with Vietnamese case.

In the case of U.S. manufacturing industry with firm-level data in the period of 1987 to 1996, Keller and Yeaple (2009) show that FDI improves the domestic firms' productivity especially in the high-tech sectors than the low-tech sectors. The small firms with lower productivity in comparison with the frontier productivity benefit more from FDI spillovers than the larger and more productive firms. In this research, the authors also use instrumental variables estimation and find stronger spillovers effect than previous studies. The instrument variables likely avoid the possibility of endogeneity of FDI in case that FDI is intended on downward for market expanding or upward for high-productivity growth. The two IVs are changes in shipping costs and tariffs and lagged level of the real exchange rate interacted with industry dummies. The FDI spillovers account for between 8% to 19% of productivity growth of U.S. firms. The changes in FDI spillovers effect after using IV variable will be given in result section.

**3. Description of data**

This section describes data for empirical analysis. Firm-level data and industry-level data are extracted from Vietnamese Annual Enterprises Survey (VAES) by General Statistics Office of Vietnam (GSO) from the year 2004 to 2010. The survey of 2004 covers 19,910 firms in all manufacturing industries while the number of 2010 is 45,984. The information getting from these data includes balance sheet and income statement statistics such as sales, inventories, the number of full-time labors, long-term asset, short-term asset, foreign investment capital, total capital, and industry code for 5-digit, 4-digit, 2-digit, and 1-digit, and the enterprise code. Enterprise code is used to merge dataset and make the panel data. The summary statistics of firm-level data are shown in Table I.1. The definitions of the variables in this table will be given in the next section.

The second database from GSO used in this research is Input-Output (IO) Table 2007 and 2000. The table of 2000 includes 112 industries and the table of 2007 includes 138 industries. Two IO data tables are merged and aggregated and downsized to 89 industries. New 89 IO industries table are merged with VAES data which has information of industry code at a 5-digit level to make linkages measurements at industry-level. The aggregation of the industry is made base on the official publication book of GSO named "Input-output (I/O) of Vietnam year 2007"[2].

The instrument variables also are introduced in this research. The reason why Thailand FDI statistics is used as instrumental variables will be explained in the next section. These statistics are conducted from The Board of Investment of Thailand. The data contains the number of projects, total FDI capital, total registered capital and number of employment classified by industry.

## 4. Empirical model and results

### *4.1 General model and variables description*

To find the spillover effect of FDI on the productivity of domestic firms called $Y_{ijt}$, Cobb-Douglas production function is used as a basic model in this research. In addition to the effect of labor and capital and other control variables ($X_{ijt}$) on the productivity of firm from the original model, FDI spillover effect would result in the change of the productivity. This spillover effect is defined by the impact of the relative relationship among FDI enterprises and domestic firms on the productivity of firms. The relationship can be measured by various methods. This paper uses two kinds of relationships. The first proxy of these linkages is presented by vector variables $FDILinks_{jt}$ at an industrial level. Vector variables $AC_{ijt/jt}$ namely absorptive capacity is the second proxy of the relationship between domestic

[2] The link to that book is http://www.gso.gov.vn/default.aspx?tabid=512&idmid=5&ItemID=10752 and link for industry comparison is http://www.gso.gov.vn/Modules/Doc_Download.aspx?DocID=12648

firm and FDI firm at both firm level and industry level. Detail explanation of these two vectors will be presented along with following empirical model.

$$lnY_{ijt} = \beta_0 + \beta_1 X_{ijt} + \beta_2 FDILinks_{jt} + \beta_3 \boldsymbol{AC_{ijt/jt}} + fe_t + fe_j + \varepsilon_{ijt} \quad (1)$$

The dependent variable log output $Y_{ijt}$ of firm *i* in sector *j* at year *t* is regressed on a vector of control variables inputs $\boldsymbol{X}_{ijt}$ and other independent variables including the vector of linkages of FDI enterprises and domestic partners/rivals at industry-level $FDILinks_{jt}$, and the absorptive capacity of domestic firms and FDI firms intra-industry and inter-industry $AC_{ijt/jt}$. In the model, the main interest parameter is $\beta_2$. This should be positive signal suggesting higher absorptive capacity, higher productivity of domestic firms.

The output $Y_{ijt}$ is calculated by the total sales of firm *i* at the end of year *t* plus inventories at the end of the year minus inventories at the beginning of the year of finished goods of this firm. This output measurement is better for productivity measurement than sales.

In the right-hand side, a vector of control variables $X_{ijt}$ includes labor, capital, material, and Herfindahl-Hirschman index which have the definition as follow. $K_{ijt}$ is the capital of the firm that is measured by long-term assets, $L_{ijt}$ is the number of labors, $M_{ijt}$ stands for material which is measured by short-term asset, all at the end of year *t.* As we can see from the summary statistic table I.1, the average output of an individual firm $Y_{ij}$ is 24 billion VND while the mean value of material $M_{ij}$ is more than seventy per centum of the output in comparison with more than fifty percent of $K_{ij}$. Each firm has 43 labors in average while the maximum number of labor is 87,225. This largest firm works in the shoe industries and is 100% FDI enterprise. Most firms in Vietnam are small and medium enterprises. The expected sign of Labor, Capital and Material are positive as suggested in theory of Cob-Douglass.

The last control variable in vector $X_{ijt}$ is an industrial level variable namely Herfindahl-Hirschman Index $HH_j$. It stands for monopolistic or competition power of an industry j. This value ranges from close to 0 to 1 (Sjöholm, 1999).

$$HHIj = \sum_{i\ for\ all\ i \epsilon j} \left(\frac{Sale_i}{Sale_j} * 100\right)^2 \quad (2)$$

If there is only one firm in industry j, then $HHIj=100^2=10.000$. This means the market is the monopoly. If there are many firms in an industry where the $Sale_i$ of each firm is not far different from other firms, $HHI_j$ is close to 0, and the market is perfect competition. If there are some big companies that have majority market shares, the $HHI_j$ becomes larger. The market transforms from competition to monopoly depending on how big market share of some largest enterprises is in that industry. The bigger the value of this index, the more concentration of the industry, or only a few firms have majority market share and vice versa. This index should have a negative relationship with the productivity of firms. The mean value of this index is around 181 for all industries of Vietnam with standard deviation of 504 and the min value is 11 to max value of 9678.

To summarize expected significance of these control variables, the *hypothesis 1* for them is: *Labor, capital, and material have a positive relationship with the output of a firm, while the more competitive the market is (or Herfindahl index is low), the more productive the firms are.*

Besides the control variables, one of interest vector variables in this research is the $FDILinks_{jt}$. This group of variables includes Horizontal, Backward and Forward linkage of FDI firms with domestic firms.

The domestic firms in developing countries are assumed to absorb the better productive technology or know-how from foreign affiliates because they often come from the more advanced economy, both at horizontal linkages and vertical linkages, or local enterprises have to exit the market under the competition of FDI enterprises. It is

not easy to get the data to measure this kind of horizontal or vertical contract between FDI and domestic firms at firm level. Therefore, this research follow (Javorcik, 2004) and (Aitken & Harrison, 1999) to measure these relationships at industry level. However, this research aggregates more detail manufacturing industry level than the two previous papers (47 industries in comparison with 22 industries).

*Hypothesis 2: The stronger the vertical linkages, the higher the productivity and the stronger the horizontal linkage, the less the productivity of domestic firm.*

$HorizontalFDI_{jt}$ is measured by FDI presence in the sector *j* at time *t* that is defined as average foreign equity share in the sector weighted by the share of firm in industry output. $FShare_{it}$ is foreign equity share of firm *i* at time t.

$$HorizontalFDI_{jt} = \sum_{i\ for\ all\ i \in j} FShare_{ijt} * Y_{ijt} / \sum_{i\ for\ all\ i \in j} Y_{ijt} \quad (3)$$

This indicator is higher with the higher foreign ownership and output Y of foreign affiliates within the industry.

Vertical FDI linkages include $BackwardFDI_{jt}$ and $ForwardFDI_{jt}$. $BackwardFDI_{jt}$ is the *Backward* relationship *of FDI* firm with industry *j*. It is the proxy of relationship between FDI enterprises in all industries *k* except *j*, and their domestic suppliers in industry *j*. The formula of $BackwardFDI_{jt}$ is as followed:

$$BackwardFDI_{jt} = \sum_{k\ if\ k \neq j} \propto_{jk} HorizontalFDI_{kt} \quad (4)$$

where $\propto_{jk}$ is the element of inverse matrix (Leontief matrix) that is the proportion of sector *j* output (direct and indirect) supply to sector *k*. The BackwardFDI linkage I use here, which is backward of FDI with industry j, is different with backward linkage in the input-output table. FDI enterprises are at downstream while other enterprises are at upstream. If this value is higher, it means that demand for intermediate goods from industry j necessary for production of FDI enterprises in other sectors is higher. In other

words, FDI firms demand intermediate goods from sector j. This value is calculated from input-output table 2000 of Vietnam for data from 2004 to 2006 and from input-output table 2007 of Vietnam for data 2007-2010. The industries level j which is used in this research are as detailed as 89 industries for the whole economy and 47 industries for manufacturing after downsize about more than 600 industries of 5-digit level industry of VAES, 138 industries in IO table 2007, and 112 industries in IO table 2000. Input supply within sector j is not included because its effect is already calculated in the formula of $\text{HorizontalFDI}_{\text{kt}}$. The value of this variable is bigger if the share of foreign equity in sectors k supplied by sector j and proportion of sector j output supply to sector k is greater.

The relationship between FDI enterprises in all industries *m* except *j*, and their distributors or customers in industry *j* $ForwardFDI_{jt}$ is estimated as followed:

$$ForwardFDI_{jt} = \sum_{m\ if\ m \neq j} \sigma_{jm}\, HorizontalFDI_{mt} \quad (5)$$

$\sigma_{jm}$ is element of inverse matrix (Leontief matrix) that is the share of inputs purchased by industry *j* from industry *m* in total (direct and indirect) inputs sourced by sector *j*. FDI firms are suppliers for sector j. $ForwardFDI_{jt}$ means Forward linkage of FDI firm with industry j. The purchase within the sector *j* is excluded because it is already presented in the formula. Actually, the export of foreign affiliates should be eliminated in $HorizontalFDI_{mt}$ because only domestic distributors should be the subject in this study. However, due to the lack of export data for every year from 2004 to 2010, the export of foreign enterprises is not eliminated of this study. Value of this variable has a positive relationship with the share of foreign output in the upstream sector *m*.

Among these three linkages, Backward linkage of FDI firms with domestic firms has highest mean value (0.82) while Horizontal linkage mean value is only 0.12 and Forward linkage is only 0.22. The minimum value of Horizontal linkage is equal to 0. It

means that in some industries there is no FDI enterprise. Even though Vietnam does not have good supporting industries compared with some neighbor countries but the statistics suggests that FDI inflows to Vietnam tends to find domestic suppliers through backward linkage than seeking for market or distributors in local market.

The most interest parameter is $\beta_3$ with absorptive capacity. The idea of absorptive capacity measurement between firm *i* in sector *j* and foreign affiliates in the same sector is based on research of Girma (2005) and Kokko (1994). While Girma defines absorptive capacity as the level of Total Factor Productivity (TFP) in the previous period divided by the maximum level of TFP within the industry, Kokko measures it by value added per employee between domestic and foreign firms also in industry level. This paper defines absorptive capacity by four ways for robust check purpose. First, it is measured by the ratio between labor productivity of domestic firm and foreign affiliates at both firm-level $AC_{ijt}$ and industry-level $AC_{jt}$ and adjusted by the foreign equity share in each firm. Distance between productivity of domestic firm and the average FDI's firms' technology intra-industry is considered in this research instead of frontiers because it is supposed that any firm which has above average technology power would have some absorptive capacity.

*Hypothesis 3: The greater the absorptive capacity, the greater the productivity.*

The formula of absorptive capacity at firm-level with labor productivity is:

$$ACL_{ijt} = \frac{LP_{ijt}}{LP^{f}_{jt}} = \frac{\frac{Y_{ijt}}{L_{ijt}}}{\frac{\sum_{i=1}^{F}\left(\frac{Y_{ijt}}{L_{ijt}}\right)*FShare_{ijt}}{\sum_{i=1}^{F} FShare_{ijt}}} \quad (6)$$

The formula of absorptive capacity at industry-level with labor productivity is:

$$ACL_{jt} = \frac{LP_{jt}}{LP^{f}_{jt}} = \frac{\frac{\sum_{i=1}^{J}\frac{Y_{ijt}}{L_{ijt}}}{J}}{\frac{\sum_{i=1}^{F}\left(\frac{Y_{ijt}}{L_{ijt}}\right)*FShare_{ijt}}{\sum_{i=1}^{F} FShare_{ijt}}} \quad (7)$$

In formula (6), the numerator $LP_{ijt} = Y_{ijt}/L_{ijt}$ stands for Labor Productivity (LP) of firm i whereas $LP_{jt}^{f} = \frac{\sum_{i=1}^{F}\left(\frac{Y_{ijt}}{L_{ijt}}\right)*FShare_{ijt}}{\sum_{i=1}^{F} FShare_{ijt}}$ is the proxy of Foreign Labor Productivity of industry j. This indicator is defined by average LP of foreign affiliates weighted by share of the foreign equity of each firm in the industry. F is a total number of foreign affiliates of this sector. A firm is considered as a foreign affiliate when it has from 10% foreign equity share upwards. The denominator of formula (7) is the same with that of formula (6) and they are all industry-level measurement. The thing which makes formula (6) and formula (7) different is that formula (6) is the absorptive capacity at firm-level when formula (7) is the absorptive capacity at industry-level with labor productivity of industry j at the numerator $LP_{jt} = \frac{\sum_{i=1}^{J}\frac{Y_{ijt}}{L_{ijt}}}{J}$ where J is total number of firms in this sector.

Beside labor productivity, this research uses the average total factor productivity (ATFP) in the formula of absorptive capacity.

Absorptive capacity at firm-level formula with ATFP is:

$$ACLK_{ijt} = \frac{ATFP_{ijt}}{ATFP_{jt}^{f}} = \frac{ln\frac{Y_{ijt}}{L_{ijt}} - \alpha ln\frac{K_{ijt}}{L_{ijt}}}{\frac{\sum_{i=1}^{F}\left(ln\frac{Y_{ijt}}{L_{ijt}} - \alpha ln\frac{K_{ijt}}{L_{ijt}}\right)*FShare_{ijt}}{\sum_{i=1}^{F} FShare_{ijt}}};\ i \in j \quad (8)$$

Absorptive capacity at industry-level formula with ATFP is:

$$ACLK_{jt} = \frac{ATFP_{jt}}{ATFP_{jt}^{f}} = \frac{\frac{\sum_{i=1}^{J}(ln\frac{Y_{ijt}}{L_{ijt}} - \alpha ln\frac{K_{ijt}}{L_{ijt}})}{J}}{\frac{\sum_{i=1}^{F}\left(ln\frac{Y_{ijt}}{L_{ijt}} - \alpha ln\frac{K_{ijt}}{L_{ijt}}\right)*FShare_{ijt}}{\sum_{i=1}^{F} Fshare_{ijt}}};\ i \in j \quad (9)$$

The value of α equals to 1/6 according to the regression model and research of Tomiura (2007). Instead of using Labor Productivity in the calculation the absorptive capacity like (6) and (7), the formulas of (8) and (9) use $ATFP_{ijt} = ln\frac{Y_{ijt}}{L_{ijt}} - \alpha ln\frac{K_{ijt}}{L_{ijt}}$.

According to the statistics in Table I.1, the average value of absorptive capacities at firm-level and industry-level in both aspect LP and ATFP are quite similar. Meanwhile, the average absorptive capacities calculated by ATFP is higher than the one measured by LP, both average values are lower than 1. It means that domestic firms have relatively lower productivity than FDI firms.

**Table I.1: Summary statistics**

| Variable | N | Mean | Sd | Min | Max |
|---|---|---|---|---|---|
| Yij | 1,140,534 | 24,240 | 445,583 | 1 | 112,000,000 |
| Kij | 1,040,221 | 13,193 | 639,552 | 1 | 260,000,000 |
| Lij | 1,138,610 | 44 | 390 | 1 | 87,225 |
| Mij | 1,136,688 | 18,628 | 704,390 | 1 | 329,000,000 |
| HorizontalFDIij | 1,140,534 | 0.12 | 0.16 | - | 0.91 |
| BackwardFDIj | 1,140,020 | 0.82 | 0.65 | 0.00 | 1.70 |
| ForwardFDIj | 1,140,020 | 0.22 | 0.20 | 0.02 | 1.33 |
| HHIj | 1,140,534 | 181 | 504 | 11 | 9678 |
| ACLKij | 1,032,587 | 0.97 | 1.24 | -254.10 | 216.24 |
| ACLKj | 1,133,845 | 0.97 | 0.96 | -132.61 | 26.28 |
| ACLij | 1,131,925 | 0.55 | 6.78 | - | 3,480.99 |
| ACLj | 1,133,845 | 0.57 | 4.71 | 0.01 | 708.36 |

### *4.2. Effects of Absorptive Capacity on Productivity*

Table I.2 shows that the sign of the interested parameter for absorptive capacity is positive as expected. The higher the absorptive capacity is, the higher the productivity of domestic firm is. Main results of the general model are presented in this table and will be discussed as follows.

The column (1) is the result of control variables: capital, labor, material, and Herfindahl-Hirschman (HH) index which presents market competition power. All of the control variables that show expected results such as capital, labor, and material have a positive impact on the productivity of firms. The highest magnitude belongs to labor which is about 6 times higher than capital while the material is about 4 times. This result suggests that the most important inputs of Vietnamese firms are labor and material, capital is not that important for the development of firms. This result is also evidence from which we use the value of $\alpha$ is 1/6 for the formula to measure the ATFP at firm level. HH has a negative impact on the productivity of the firm. This measurement is at the industry level, it means that within a highly monopolized industry where some firms have a very large market share, the productivity of firm is lower than the firm in other industry with many small companies. The robust checks for these dependent variables have consistent and stable value of parameters through columns (2) to columns (6).

Three important variables to determine linkages of FDI firm with domestic firm in an industry are Horizontal, Backward and Forward linkages. The linkage which has strongest positive impact on the productivity of firm is forward linkage which has the same power as the effect of labor. About one percent increases in Forward linkage make 0.6 percent increase in productivity of firm. In another word, if one industry has higher output and foreign equity at downstream sector and the domestic firm is at the upstream sector, that industry has the higher output of domestic firms. Backward linkage also has

a positive relationship with the output of firm but opposite side in case of horizontal linkage. The more concentration of FDI firm in one industry, the less output of the domestic firm. This effect is known as "crowding out" effect.

**Table I.2: Relationship between domestic firm's performance and absorptive capacity measured by Labor productivity**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| VARIABLES | lnYij | lnYij | lnYij | lnYij | lnYij | lnYij |
| lnKij | 0.0919*** | 0.0895*** | 0.0905*** | 0.0910*** | 0.0881*** | 0.0888*** |
| | (0.00293) | (0.00293) | (0.00291) | (0.00293) | (0.00291) | (0.00293) |
| lnLij | 0.526*** | 0.531*** | 0.538*** | 0.528*** | 0.544*** | 0.533*** |
| | (0.00487) | (0.00487) | (0.00485) | (0.00487) | (0.00485) | (0.00487) |
| lnMij | 0.389*** | 0.380*** | 0.385*** | 0.387*** | 0.376*** | 0.379*** |
| | (0.00327) | (0.00330) | (0.00325) | (0.00328) | (0.00328) | (0.00331) |
| HHIj | -0.424*** | -0.225** | -0.452*** | -0.667*** | -0.255*** | -0.484*** |
| | (0.0937) | (0.0960) | (0.0930) | (0.0955) | (0.0953) | (0.0989) |
| HorizontalFDIj | | -0.992*** | | | -0.978*** | -0.822*** |
| | | (0.0626) | | | (0.0621) | (0.0645) |
| BackwardFDIj | | 0.218*** | | | 0.229*** | 0.236*** |
| | | (0.0274) | | | (0.0272) | (0.0274) |
| ForwardFDIj | | 0.662*** | | | 0.648*** | 0.561*** |
| | | (0.0508) | | | (0.0504) | (0.0516) |
| ACLij | | | 0.0164*** | | 0.0164*** | |
| | | | (0.000370) | | (0.000369) | |
| ACLj | | | | 0.0896*** | | 0.0792*** |
| | | | | (0.00700) | | (0.00728) |
| Constant | 2.701*** | 2.652*** | 2.687*** | 2.659*** | 2.635*** | 2.596*** |
| | (0.0256) | (0.0274) | (0.0254) | (0.0258) | (0.0272) | (0.0279) |
| | | | | | | |
| #observation | 206,158 | 206,158 | 206,156 | 206,157 | 206,156 | 206,157 |
| R-squared | 0.263 | 0.265 | 0.274 | 0.264 | 0.276 | 0.266 |
| #firm | 71,498 | 71,498 | 71,497 | 71,498 | 71,497 | 71,498 |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The most important variable here is absorptive capacity at firm level and industry level. If the domestic firm has higher ATFP in comparison with average FDI productivity, their absorptive capacity is higher. The result shows that if absorptive capacity increases one percent, the productivity increase about 0.02 percent to 0.09

percent. This significant is at 99% level and the magnitude is 0.0164 for ACL at firm level and 0.0792 or 0.0896 for ACL at industry level.

The Table I.3 shows consistent result with Table I.2 after replacing labor absorptive capacity by ATFP absorptive capacity. This relationship even is stronger than labor absorptive capacity (from 0.2 to 2) and positive.

**Table I.3: Relationship between absorptive capacity that measured with ATFP and productivity of domestic firms**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | lnYij | lnYij | lnYij | lnYij |
| | | | | |
| lnKij | 0.144*** | 0.0928*** | 0.141*** | 0.0904*** |
| | (0.00219) | (0.00292) | (0.00218) | (0.00292) |
| lnLij | 0.636*** | 0.524*** | 0.643*** | 0.530*** |
| | (0.00365) | (0.00487) | (0.00364) | (0.00487) |
| lnMij | 0.269*** | 0.392*** | 0.258*** | 0.383*** |
| | (0.00247) | (0.00328) | (0.00248) | (0.00330) |
| HHIj | -0.0509 | -0.385*** | 0.174** | -0.194** |
| | (0.0699) | (0.0936) | (0.0714) | (0.0959) |
| HorizontalFDIj | | | -0.910*** | -0.963*** |
| | | | (0.0465) | (0.0625) |
| BackwardFDIj | | | 0.464*** | 0.227*** |
| | | | (0.0204) | (0.0273) |
| ForwardFDIj | | | 0.464*** | 0.645*** |
| | | | (0.0378) | (0.0508) |
| ACLKij | 2.074*** | | 2.080*** | |
| | (0.00633) | | (0.00631) | |
| ACLKj | | 0.229*** | | 0.228*** |
| | | (0.0139) | | (0.0139) |
| Constant | 0.977*** | 2.461*** | 0.882*** | 2.406*** |
| | (0.0198) | (0.0294) | (0.0211) | (0.0312) |
| | | | | |
| Observations | 206,154 | 206,157 | 206,154 | 206,157 |
| R-squared | 0.590 | 0.265 | 0.594 | 0.267 |
| Number of tco | 71,498 | 71,498 | 71,498 | 71,498 |

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

### *4.3. Nonlinear relationship between Absorptive Capacity and Spillover Effect*

Effect of absorptive capacity should be non-linear (Girma, 2005) and change the speed when their productivity is closer to FDI firm. The data description shows that mean value of absorptive capacity is less than 1 implies that domestic firm has lower productivity than FDI firms. Spillover effect should increase where absorptive capacity is low, the speed of this rising is slowdown and will decrease after reaching the vertex. The relationship between absorptive capacity and spillover effect maybe quadratic function and is presented as follow:

Model:

$$lnY_{ijt} = \beta_0 + \beta_1 X_{ijt} + \beta_2 FDILinks_{jt} + \boldsymbol{\beta_3 AC_{ijt/jt}} + \boldsymbol{\beta_3' AC_{ijt/jt}^2} + fe_t + fe_j + \varepsilon_{ijt} \quad (10)$$

The parameter $\beta_3$ should be positive while $\beta_3'$ should be negative as my assumption and the parabola can open down.

Table I.4 displays the estimation result of (10). For all type of AC (at firm level or industry level, measured by labor productivity or ATFP), the AC is significantly positive and $AC^2$ is significantly negative, this relationship confirms the open down parabola relationship between absorptive capacity and productivity of firm. As a related finding of the relationship of absorptive capacity and productivity, Girma (2005) discovers the presence of nonlinear threshold effects: the productivity benefit from FDI increase with absorptive capacity until some threshold level beyond which it becomes less pronounced. Stock, Greis, and Fischer (2001) also find that an "inverted_U" shape suggests diminishing returns for absorptive capacity.

IV estimation results are reported in Table I.5. In the first-stage regression, all the right-hand side variables are used. The problem of weak instrument is not affected and that is confirmed by tests of endogeneity, weak instrument and over-identifying restriction.

As the most important point to note from the second-stage regressions in this table, even after instrumenting absorptive capacity with foreign capital share of Thailand in each industry, I confirm that absorptive capacity is significantly positively related with the output of firm, either at firm-level or industry-level. Consequently, the robustness of my main findings reported in the previous section is confirmed by this IV estimation.

**Table I.4: Non-linear relationship between absorptive capacity and productivity of firms**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | lnYij | lnYij | lnYij | lnYij |
| lnKij | 0.0859*** | 0.0885*** | 0.159*** | 0.0919*** |
| | (0.00285) | (0.00292) | (0.00182) | (0.00292) |
| lnLij | 0.585*** | 0.534*** | 0.678*** | 0.527*** |
| | (0.00478) | (0.00487) | (0.00304) | (0.00486) |
| lnMij | 0.364*** | 0.378*** | 0.214*** | 0.388*** |
| | (0.00322) | (0.00330) | (0.00208) | (0.00331) |
| HHIj | -0.192** | -0.421*** | 0.401*** | -0.0827 |
| | (0.0934) | (0.0990) | (0.0596) | (0.0958) |
| HorizontalFDIj | -0.988*** | -0.778*** | -0.932*** | -0.934*** |
| | (0.0609) | (0.0646) | (0.0389) | (0.0624) |
| BackwardFDIj | 0.269*** | 0.250*** | 0.561*** | 0.248*** |
| | (0.0266) | (0.0274) | (0.0170) | (0.0273) |
| ForwardFDIj | 0.610*** | 0.519*** | 0.378*** | 0.612*** |
| | (0.0494) | (0.0517) | (0.0316) | (0.0507) |
| ACLij | 0.0735*** | | | |
| | (0.000845) | | | |
| ACLij2 | -3.27e-05*** | | | |
| | (4.37e-07) | | | |
| ACLj | | 0.171*** | | |
| | | (0.0110) | | |
| ACLj2 | | -0.0200*** | | |
| | | (0.00180) | | |
| ACLKij | | | 3.061*** | |
| | | | (0.00665) | |
| ACLKij2 | | | -0.136*** | |
| | | | (0.000561) | |
| ACLKj | | | | 0.728*** |
| | | | | (0.0259) |
| ACLKj2 | | | | -0.0580*** |
| | | | | (0.00254) |
| Constant | 2.575*** | 2.543*** | 0.199*** | 1.944*** |
| | (0.0267) | (0.0283) | (0.0178) | (0.0371) |
| | | | | |
| Observations | 206,156 | 206,157 | 206,154 | 206,157 |
| R-squared | 0.305 | 0.267 | 0.717 | 0.270 |
| Number of tco | 71,497 | 71,498 | 71,498 | 71,498 |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

### *4.4. Instrument variables*

Although it is included in the right-hand side of the regressions, AC might not be exogenous. For instance, AC may rise as the result of high-sale of firm. To solve the endogeneity problem, the following two variables are used as instrument variables (IV).

These instruments are the share of foreign capital in total registered capital of Thailand by industries (FShareT2), and share of Foreign Capital in total capital of the FDI projects in Thailand by Industries (FShareT1). These two variables can safely be regarded as exogenously given for current sales adjusted for change in inventory (Y) of firms in Vietnam in the same industry but are likely to be correlated with AC from the following reasons. First, structure of FDI inflow to Thailand and to Vietnam is very similar, particularly in manufacturing industry. Thailand and Vietnam are located inside the South-East Asia while Thailand is rival of Vietnam in terms of FDI attractiveness. Three biggest FDI home countries in Vietnam, Korea, Japan, and Singapore also invest in Thailand and these investors are concerned with the whole market within the region not only Vietnam. The foreign investor looking for labor or resource in Vietnam may find the market or same resource in Thailand. The FDI inflows may have a relationship with AC of Vietnam.

Model:

First-stage:

$$\boldsymbol{AC_{jt}} = \gamma_0 + \gamma_1 X_{ijt} + \gamma_2 \boldsymbol{ThaiFDI_{jt}} + \epsilon_{ijt}$$

Second-stage:

$$lnY_{ijt} = \beta_0 + \boldsymbol{\beta_2 AC_{jt}} + \beta_3 X_{ijt} + \varepsilon_{ijt}$$

Second, Thailand and Vietnam are two competitors in attracting FDI because their locations are close, and they have same economic development level and manufacturing structure. Vietnam is trying to learn from Thailand how to upgrade the manufacturing industry as well as use foreign direct investment as an important source of capital to push the

development of domestic firms. These common features raise the idea that FDI inflows into Vietnam may be affected by FDI inflows into Thailand. In other word, FDI inflows into Thailand could be good instrument variable for FDI inflows into Vietnam. The idea to choose IV in this research is inspired from the research of Jordaan (2011) which shows the intra-industry FDI presence measured by employment share of foreign-owned firms within each industry in Mexico is one endogenous variable that is affected by the US FDI intensity.

In this research, the FDI participation at firm level $ACLK_{ijt/jt}$ is treated as instrumented variable which can be impacted by Thailand FDI inflows. The data of Thailand FDI is aggregated from the FDI report by BOI Thailand. The data of Thailand includes statistics of number of projects, investment (million Baht), registered capital (million Baht), and employment at industry level through the year 2007 to the year 2010. Projects are those to be approved by BOI by year and classified by sub-sector. Investment is total foreign investment capital by projects with foreign capital of at least 10% (million Baht). Registered capital is an additional registered capital amount (not registered capital of the whole company) for projects approved by BOI investment promotion which can be either new or expansion projects. In many cases, firms do not invest new capitals for their expansion project. Registered capital is divided into Thailand and Foreign capital. Employment is number of labors for the incremental projects including Thailand labors and foreign labors.

The result of IV regression is shown in table I.5. This table confirms the positive backward linkage of FDI and domestic firms and productivity, but the signals for HHIj, Horizontal linkage and Forward linkage change into the opposite side. This result suggests that the present of FDI inflows of Thailand in the same industry affects the spillover effect of FDI in Vietnam.

**Table I.5: Relationship between Absorptive Capacity instrumented variable and productivity of firms.**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | IV 1st | IV 2nd | IV 1st | IV 2nd |
| VARIABLES | ACLKj | lnYij | ACLKij | lnYij |
| | | | | |
| lnKij | -0.00460*** | 0.0471*** | -0.0371*** | 0.123*** |
| | (0.000235) | (0.00377) | (0.000857) | (0.00608) |
| lnLij | 0.0163*** | 0.596*** | -0.0217*** | 0.705*** |
| | (0.000293) | (0.00557) | (0.00107) | (0.00535) |
| lnMij | -0.00940*** | 0.562*** | 0.103*** | 0.278*** |
| | (0.000294) | (0.00503) | (0.00108) | (0.0140) |
| HorizontalFDIj | -0.114*** | 0.457*** | -0.303*** | 0.754*** |
| | (0.00435) | (0.0740) | (0.0159) | (0.0830) |
| BackwardFDIj | -0.0768*** | 1.302*** | -0.184*** | 1.493*** |
| | (0.00176) | (0.0264) | (0.00646) | (0.0298) |
| ForwardFDIj | 0.132*** | -2.167*** | 0.358*** | -2.539*** |
| | (0.00331) | (0.0557) | (0.0121) | (0.0675) |
| HHIj | -0.404*** | 2.144*** | -0.755*** | 2.652*** |
| | (0.00655) | (0.122) | (0.0242) | (0.140) |
| FShareT1 | -0.117*** | | -0.118*** | |
| | (0.00186) | | (0.00682) | |
| FShareT2 | 0.161*** | | 0.219*** | |
| | (0.00184) | | (0.00673) | |
| ACLKjhat | | 3.382*** | | |
| | | (0.177) | | |
| ACLKijhat | | | | 2.463*** |
| | | | | (0.132) |
| Constant | 0.942*** | -1.587*** | 0.356*** | 0.684*** |
| | (0.00221) | (0.187) | (0.00805) | (0.0731) |
| | | | | |
| Observations | 79,434 | 77,800 | 77,798 | 77,800 |
| R-squared | 0.210 | 0.691 | 0.133 | 0.691 |

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

## 5. Concluding remarks

Flowing into Vietnam for about three decades, even the linkages of FDI firms and domestic firms are not too strong, these linkages almost have positive impact on the productivity of domestic firms particularly the forward and backward linkages. FDI enterprises choose higher productivity firms to be their supplier or distributors. At the same time, on the other hand,

during being customers or suppliers of foreign firms, domestic enterprises increase their productivity through learning-by-doing process to meet the requirement of FDI firm.

The reason why horizontal linkages effect significantly negatively on the output of domestic firms is because if FDI firms choose domestic market as their main market in industry such as making accessory providers, or retail sectors, they have stronger competition power than domestic firms and may kick them out of the market or reduce their market share.

The most important and new variable in this research is absorptive capacity of domestic firm or domestic industry relatively with average productivity of FDI firm. If the domestic firm has a higher absorptive capacity, it will have higher productivity. This relationship is strong and positively significant at all firm or industry levels as well as the different measurement based on labor productivity or average total factor productivity. The measurement of absorptive capacity in this research is new. Non-linear relationship is also confirmed, which means that the higher absorptive capacity of domestic firm, the higher their productivity. However, the U-inverted quadratic function shows that until threshold point, even AC is higher, the productivity of domestic firm got the maximum point and goes down.

The endogeneity problem which may take place in the regression function is eliminated by instrumented absorptive capacity with presence of foreign direct investment in Thailand because the similarity of FDI capital through industries between Thailand and Vietnam. The IV instruments variable confirms the positive relationship between AC and productivity of domestic firms.

While this finding is strong with new AC variables, there still remain several important issues. For example, the linkages between domestic and foreign firms should be measured not only at industry level but also at firm level. As yet another extension, absorptive capacity with different home countries will reveal additional policies suggestions for discussion on FDI spillover effects.

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# CHAPTER 2

# SPATIAL ATTENUATION OF AGGLOMERATION EXTERNALITY: EVIDENCE FROM FIRM-LEVEL DATA IN VIETNAM[*]

August 5, 2016

**Abstract**

Based on firm-level data in Vietnam, we confirm that the agglomeration spillover from the domestic core attenuates with distance among domestic firms, but find that the attenuation speed significantly accelerates at the former national border among private firms even after four decades since the reunification. Robustness of our main findings is confirmed with historical data of regional population before the North-South division as an instrumental variable. Productivity of all firms, especially foreign-owned firms, is sensitive to the market potential or the presence of other firms.

Keywords: agglomeration; distance; border effect; productivity; firm-level data

JEL Classifications: R12, F23, N95, L22, O18

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## 1. Introduction

Agglomeration is one of the central topics in spatial economics. Previous literature has established that agglomeration externality attenuates with distance. However, various factors should affect the speed of attenuation. The border effect is critical, as has been extensively analyzed in international economics. Foreign-owned firms are also likely to differ from domestic firms in receiving and generating information spillovers. This paper examines spatial attenuation of agglomeration spillover based on firm-level data in Vietnam, and investigates whether the former national border matters for different ownership types of firms after four decades since the reunification.

As surveyed by Rosenthal and Strange (2004), agglomeration externality has been established as a stylized fact. On the geographic scope, previous studies report that the spillover decays rapidly with distance (e.g. Duranton and Overman 2005). However, the spillover does not attenuate monotonically, affected by borders. On the border effect, German reunification has been actively studied as a natural experiment case. Redding and Sturm (2008) is a prime example of research uncovering persistent border effect. The investigation of such historical division and reunification provides us of a precious opportunity to discuss the impact of border on economic activities. Differences in corporate organization, especially foreign-owned or state-owned compared with privately-owned firms, should also matter in spillovers, but empirical evidence on this aspect has so far been limited.[3]

Vietnam is a suitable case for our research, as the country experienced the division and the reunification in the last century. Vietnam was divided into South and North with the border at the 17-degree latitude after the end of World War II until the reunification of two regions in 1975. The contrast between these two divided countries was clear in economic system: capitalist South and socialist North. As the reunification was realized by the victory of North

[3] For example, Henderson (2003) finds that single-plant firms are more sensitive to externality than multi-plant firms in the U.S. A brief survey of related literature will be given in the next section.

and withdrawal of U.S. from South, state-owned enterprises (SOE) remain powerful in some market segments of this country. As four decades passed since the reunification, however, Vietnam has recently become active in economic reforms since the start of Doi Moi (meaning renovation in Vietnamese) in the mid-1980s. Vietnam became a member of ASEAN and its free trade area in 1995, gained normal access to U.S. market by signing the bilateral trade agreement in 2001, joined World Trade Organization (WTO) in 2007, and singed Trans-Pacific Economic Partnership Agreement (TPP) with developed countries such as U.S., Japan, and Australia in 2015. Foreign multinationals actively established affiliates in Vietnam to seek low wage for export platform purpose in labor-intensive industries. This paper compares firms in North versus South as well as various types of firms (SOE, private domestic firms, and foreign-owned firms).

Due to its natural geography of Vietnam as a long country like a Hoteling's linear city, it is natural to discuss spatial attenuation of agglomeration spillover with distance from the core. While Hanoi is the national capital and the political center, Ho Chi Minh has been the dominant economic core in Vietnam. Ho Chi Minh, as a city alone, occupies nearly one-fifth of Vietnam's GDP.

To preview our principal results, the productivity of domestic firms declines with the distance from the domestic economic core Ho Chi Minh, but the attenuation speed significantly accelerates at the former border even after four decades since the reunification among private domestic firms. The robustness of this finding of persistent border effect is confirmed with historical data (regional population before the division) as an instrumental variable. As IV estimates control for regional variations in natural advantages, the persistent border effect is likely to be rooted in second-nature factors. The finding of the persistent border effect especially in private firms rather than SOEs indicates that it is mainly due not to public policy or regulation but to spontaneously established patterns of private business

networks. On the other hand, the productivity of foreign firms, virtually all of which are established only recently, is free from the effect of the former border, but instead sensitive to the market potential and to the concentration/presence of other firms.

The rest of this paper is organized as follows. Section 2 reviews related literature. Section 3 describes Vietnamese firm-level data and historical data used for our analyses. Section 4 explains empirical specifications and reports estimation results. Section 5 adds concluding remarks.

## 2. Literature review

As this paper links the agglomeration literature with accumulated studies of the border effect, this section briefly reviews both strands of research. This section is not intended to be an exhaustive list of all papers on these topics but served as a starting point for our empirical analysis.

As surveyed by Rosenthal and Strange (2004), agglomeration has been one of the central research topics in economic geography. Previous studies have shown that the effect declines steeply with distance (e.g. Andersson et al. 2004, Duranton and Overman 2005, Rice et al. 2006, and Soest et al. 2006).[4] However, agglomeration spillover does not monotonically attenuate with geographic distance but is also affected by borders. Henderson (2003) finds that the plant's productivity is influenced by employment activities in the same county but not by those in neighboring counties in the U.S. Many previous studies of knowledge spillovers, such as Belenzon and Schankerman (2013), Li (2014), and Peri (2005), find that citations to

[4] Andersson et al. (2004) examine the impact of an exogenous policy change (university relocations) on regional productivity in Sweden, and find that about 75% of spillover occurs within 100 kilometers. Rice et al. (2006) discover that the effect on productivity declines sharply with travel time in U.K. by using historical population weighted by geographic distance as an instrumental variable. Soest et al. (2006) report that the effect on employment dies out quickly with distance in the case of South-Holland. Duranton and Overman (2005) find that localization of industries takes place at small scales below 50 kilometers among U.K. establishments.

patents decline sharply with distance and are strongly constrained by borders, even by state borders within the U.S.

While previous research often examined the state border in the federated U.S., the national border should be more critical in discussing agglomeration or spillover. The border effect has been repeatedly examined in international trade literature. The case of German reunification has recently attracted attention as a natural experiment in this context. For example, Redding and Sturm (2008) find that the population growth in the cities in Western Germany closer to the East-West German border was substantially lower than other Western German cities after the East-West division. Felbermayr and Gröschl (2014) detect persistent negative border effect on current commodity flows in the case of Union-Confederacy border during the Civil War in the U.S. As a study of deep impact of national border from a different angle, Alesina, and Fuchs-Schündeln (2007) find that the German division for 45 years has changed people's preferences, especially fundamental policy stances on state intervention. We examine whether the border between North and South Vietnam, which had been effective for around three decades, has a persistent impact on productivity of firms after four decades since the reunification.

In spite of accumulation of established results on agglomeration, several important issues remain unexplored. Among them, agglomeration spillovers are likely to be affected by the corporate organization, such as ownership type. Rosenthal and Strange (2003) compare subsidiaries vs. non-subsidiaries in the effect of agglomeration on births of new local establishments but detect no clear patterns in the U.S. case.[5] Based on the U.S. census data, Henderson (2003) finds that the productivity of single-plant firms is more sensitive to externality than that of multi-plant firms. In a slightly different context, Crozet et al. (2004) find that foreign firms are strongly attracted to agglomeration of domestic firms in France,

[5] They interpret this inconclusive result as suggesting that "subsidiary status is too rough a measure to capture the influence of a hierarchical corporate structure" (p.387).

possibly as foreign firms compete directly against firms from other foreign countries, benefit from inter-firm mobility of qualified workers from French firms, or expect that French local firms know better about attractiveness of each region.[6]

Although many papers have recently used Vietnamese regional data, none has examined agglomeration (e.g. Brambilla et al. 2012 on household income, McCaig 2011 on poverty, and McCaig and Pavcnik 2014 on labor shift from household business). The border effect is not explicitly discussed either. The use of firm-level data combined with historical province-level population census data differentiates our research from previous studies of Vietnamese regions.

## 3. Data description

This section describes our data for empirical analysis. We construct a novel dataset by merging two distinct statistics: firm-level data from Enterprise Survey and historical province-level data from Population Census of Vietnam.

Annual Enterprise Survey by General Statistics Office covers all state-owned enterprises, all foreign-owned enterprises, and all private-owned enterprises with not less than ten workers, and randomly sampled 20% of private-owned enterprises with less than ten workers in Vietnam, and collects basic information such as sales, inventory, capital (long-term assets), labor (number of full-time workers), location, and industry codes, as in standard firm statistics in many developed countries. We define production by the sales plus changes in inventory (value at the end minus that at the beginning of the year), while many previous studies depend on sales data in estimating production function. As no data on expenditures on materials are available, we cannot calculate value-added.[7]

[6] On the other hand, Kamal (2014) finds the spillover effect is strong among the same ownership type of firms in China.

[7] Vietnamese Enterprise Survey either contains no data on workers' hours worked or tangible fixed assets distinguished from long-term assets.

The same survey also identifies firms by ownership types: SOEs (state-owned enterprises), private domestic firms, and foreign-owned firms. In Vietnam, after Foreign Investment Law of 1987, foreign investors are allowed to own 100 percent of shares in all industries except defense-related sectors. As a result of the Doi Moi reform, SOEs are required fiscal autonomy and no longer depend on export subsidies, but rarely privatized. In the statistics, SOE is defined by more than 51 percent of shares owned by the state, while foreign firms are those with not less than 49 percent of shares owned by foreigners. All other firms are categorized as private domestic firms.

Geographic locations (address) of firms are also identified in the survey. The entire Vietnam is currently divided into 63 provinces, which we merge to 59 for our research to handle changes in provincial borders during the sample period. The province is the appropriate geographical unit for our research of agglomeration, as few people move across provinces. For example, McCaig (2011) reports that only 2.2% of household heads moved across provincial boundaries in Vietnam. GDP of each province is shown in the map as Figure II.1.

This paper uses firm-level data at 2006 to avoid possible noises due to the global financial crisis at 2008. At that year, there are 3,530 SOEs, 111,537 private domestic firms, and 4,031 foreign firms in our sample. We drop firms with production, labor or capital zero or negative from our sample. The summary statistics of firm-level data are shown in Table II.1. The definitions of the variables will be given in the next section.

We also exploit historical data for instrumental variables in our regressions. Historical regional data are derived from Vietnam's Population Census, which documents regional population covering all provinces in Vietnam since 1921. As no data on firms or regional GDP are available for pre-division years, regional population data is the sole practical index to measure local economic activities. We photocopied printed various issues of Statistics

Yearbooks at National Library at Hanoi, since historical data are not provided in electronic form. The reasons for choosing regional population at a pre-division year as an instrumental variable will be explained in the next section.

## 4. Empirical results from firm-level regressions

This section explains our empirical specifications and reports estimation results from firm-level data in Vietnam. We start with the baseline specification to measure the attenuation of agglomeration spillover with distance, and then use historical data as instrumental variables to handle the endogeneity problem. In the last section, we examine how the productivity of a firm is influenced by surrounding regions. In all cases, we pay attentions to the variations across different types of firm ownership.

### *4.1. Empirical specifications*

This subsection explains our baseline specifications for empirical analyses. This paper starts with the following standard Cobb-Douglas production function

$$Q_{ijr} = A_{ijr} K_j^{\alpha_1} L_j^{\alpha_2} . \qquad (1)$$

The suffix *j* identifies firms, while the industry and the region in which the firm is located are indexed respectively by *i* and *r*. The production, capital, labor and the total factor productivity (TFP) are expressed by *Q*, *K*, *L*, and *A*, respectively. Our main target is estimating whether and how much the firm's TFP varies with the distance from the agglomerated core region. This paper estimates the following log-linear specification:

$$\begin{aligned} \ln Q_{ijr} = {} & \alpha_0 + \alpha_1 \ln K_j + \alpha_2 \ln L_j + \beta_1 \ln DistHCM_r + \beta_2 \ln DistB_r * North_r \\ & + \gamma \ln GDP_r + \delta \cdot IND_i + \theta \cdot FirmType_j + u_{ijr} \end{aligned} . \qquad (2)$$

TFP is characterized as a function of geographic factors, of which the definitions will be given in detail in what follows. The error term is denoted by *u*. Industry effects are controlled by a vector of the dummies *IND*. There are 87 industries at the two-digit level. We

also estimate the same specification separately for private domestic firms, SOEs and foreign firms without firm type dummies *FirmType*. Distinguishing these firm types is critical for current Vietnam as SOE remains powerful in some market segments even after liberalization and market reform while inward FDI is expanding amid globalization. The investigation of differences in the spillover effect across firm ownership types is also informative as a study of agglomeration and economic geography, as no previous research has so far distinguished firm types in estimating spatial attenuation of agglomeration spillover to the best knowledge of the authors.

As the key variable of our interest, the geographic distance of the region from the domestic economic core Ho Chi Minh in kilometers is denoted by *DistHCM*.[8] For firms located within Ho Chi Minh, we measure internal distance using the equation proposed by Redding and Venables (2004): $Dist = 2/3 \cdot \sqrt{Area/\pi}$ , where *Area* refers to the area of Ho Chi Minh measured in square kilometers.[9] As the established results from previous literature have confirmed agglomeration externality attenuating with the distance from the center, we expect $\beta_1$ be negative.

As we estimate the production function over firms in a cross-section format, however, we should not interpret (2) as indicating the direction of causality. The same equation could be consistent with the self-selection of more productive firms into regions nearer to the congested core with more intense competition against larger number of rival firms. We do not claim that the estimation of (2) rejects such alternative hypotheses. While Combes et al. (2012) attempt at distinguishing agglomeration from self-selection, this paper focuses on measuring the spatial attenuation of agglomeration spillover and examines how it is affected by the corporate organization and national border.

[8] We measure the distance from the capital city of each province. Identifying exact address of firms within each province is left for future independent work.
[9] This approximation is based on the average distance between two points in a circular region. The ratio of a circumference of a circle to its diameter is expressed by "π."

To capture the effect of the former national border, we introduce *DistB*, which is defined by the distance from the former national border, the 17th degree North latitude, in kilometers. We add this border distance term only for the firms located north of the former border, by interacting with the binary dummy *North*, which takes the value one for firms in the North but zero for those in the South. If the agglomeration externality decays with distance at a higher speed in the former North Vietnam, $\beta_2$ should be negative. We also estimate the model with the binary dummy *North* without interacting with *DistB* for a robustness check purpose.[10]

Although Ho Chi Minh is the dominant economic center in this country, the productivity of a firm is likely to be influenced by the size of local market. *GDP* is measured for each province. Positive $\gamma$ is predicted by the home market effect. By including local GDP in our regression, the agglomeration externality examined in this paper is after controlling for variations in local market sizes.

Although we include it on the right-hand side of the regressions (2), the own region's GDP might not be exogenous. For example, GDP may rise as a result of location of high-productivity firms in the region. GDP in a peripheral region with a limited number of firms may particularly be affected by the productivity of individual firm. To handle this endogeneity problem, we use the following two historical variables as instrumental variables (IV).[11]

The first instrumental variable is the regional population at 1943, *POP1943*. The regional population at such an early year can safely be regarded as exogenously given for current productivity of individual firms in the same province but is likely to be correlated with current GDP from the following reasons.

[10] The province crossing the former border is excluded when we define *DistB* or *North*.

[11] Even after instruments are assigned to GDP, the potential endogeneity problem cannot be ignored for the firm's choice of production factors *L* and *K*. It is however, unfortunately, difficult to find an instrument for these variables within our cross-section format. No firm-level data on expenditures on materials are available.

First, population distributions across regions before the division were not affected by North-South national border since Vietnam was a united country at that time. The spatial distribution of economic activities at that time should share some resemblance with current pattern in regions of united Vietnam.

Second, population distribution and distributions of economic activities over regions at such an early year are likely to reflect natural geographic advantages/disadvantages, such as climate, amenity, and quality of soils or water, access to the sea or navigable river, and/or abundance of other natural resources. As Vietnamese economy at that time predominantly depended on agriculture or fishery, this assumption appears reasonable. By including population distribution at 1943 in our regression, our estimates can be regarded as those after controlling for natural geography factors.

The other instrument we use for current regional GDP is the bombing intensity during the Vietnam War[12] between 1965 and 1975, *BOMB*. As Miguel and Roland (2011) note, the intensity of bombing varies substantially across regions in Vietnam. The bombing during the war after four decades is exogenous for current firms' productivity but could be correlated with current GDP. If damage of the war, such as remained explosives, for example, still affects economic activities, *BOMB* is negatively related with current GDP of the region.[13] If heavily bombed regions recovered from destruction faster than other regions, *BOMB* is instead positively related.[14] The bombing intensity is measured in terms of total U.S. bombs, missiles and rockets per square kilometers.[15]

[12] In Vietnam, this war is called as "War against U.S." This paper expresses it as Vietnam War to facilitate the understanding for international readers.
[13] The bombing intensity during the war was not systematically linked with the region's population before the war. For example, central regions near the 17th parallel were heavily bombed but the two largest cities, Saigon and Hanoi, were not.
[14] Davis and Weinstein (2002) conclude that the latter is the case in Japan after the World War II. Miguel and Roland (2011) find no significant impact of bombing during the Vietnam War on the region's poverty and consumption at 2002.
[15] Professor Gérald Roland kindly provided us with his data, which was constructed from U.S. military records and used for Miguel and Roland (2011). This dataset includes wide categories of weapons, except anti-personnel landmines.

### *4.2. Estimation results*

#### *4.2.1. Preliminary results*

Before reporting the main results, Table II.2 presents preliminary OLS results from parsimonious specifications. The dependent variable is the firm's production, as in our main specification explained in the previous section. Industry dummies and firm type dummies are included in all cases. Standard errors are clustered at the province level, as the productivity shocks of firms in the same province are likely to be correlated.

The column (1) is the regression only on the firm's primary factor of production *K* and *L* without any geographic variables. The sum of both coefficients is close to one but slightly less than one, suggesting weakly decreasing returns to scale of production in Vietnam or omitted variable bias possibly due to unavailable data on material inputs or human skills.

The columns (2) and (3) add the distance from the core and the variable for the North-South border. The distance from the former border for firms in the northern locations is used in (2), while the binary dummy for them is used in (3). In both cases, we find that the spatial attenuation of agglomeration externality and the border effect are both strongly significant. The estimated coefficient on the logarithm distance, around - 0.1, is in a comparable range with that for knowledge spillovers estimated by Peri (2005).

The last two columns of Table II.2 further add local GDP. While the border effect, both in *DistB* and the binary *North*, remains clearly significant, the distance from the core turns out to be statistically insignificant if we add the province's GDP. As pointed out in the previous section, this result could be contaminated by endogeneity problem. We must wait for IV results before discussing our main topic.

#### *4.2.2. IV results*

Table II.3 reports the estimation results with IV assigned to local GDP. In the first-stage regression, though omitted from the table, we confirm that we are not affected by the problem

of weak instruments, especially by the significantly positive association with the historical population.[16] We confirm that local GDP, even after instrumented, remains positive, but, in contrast to Table II.2, the first column of this table shows that the distance from the core becomes significant at any conventional significance level. We also confirm that the magnitude of estimated coefficient on *DistHCM* remains basically unaltered from the previous specification without local GDP in Table II.2. The distance from the former border for firms in the north remains significantly negative, as in the previous table. The estimates in Table II.3 imply that the attenuation of agglomeration spillover significantly speeds up when crossing the former national border at 17$^{th}$-degree latitude.

To explore underlying mechanism behind such persistent border effect, Table II.3 further disaggregates firms by ownership types. Instead of adding firm type dummies, the remaining three columns of this table reports regression results separately from each firm type. We emphasize two notable findings from this table.

As the first point of note, the agglomeration externality from the domestic core Ho Chi Minh decays with distance significantly only for domestic firms. Its impact on the productivity of foreign firms is only weakly detected at a generous 10% level. Remoteness from the domestic core is serious only for domestic firms.

Table II.3 also confirms that the productivity of all types of firms tends to be high in regions with larger local market. For domestic firms, even if we consider this strong home market effect, the distance from the core remains to have a significantly negative impact on productivity.

Several plausible interpretations are in order. First, although no data on exporting of goods are available within our firm-level data set, foreign firms are likely to more depend on

[16] The first-stage OLS confirms that local GDP is highly positively related with population before the North-South division. While GDP of a province declines with the distance from Ho Chi Minh, the relationship with bombing intensity during Vietnam War turns out to be insignificant. We confirm that our main results remain basically untouched whether or not *BOMB* is dropped from the first-stage regression.

foreign sales and thus less susceptible to remoteness from the domestic core market.[17] As a related finding supporting this interpretation, the productivity of foreign firms appears negatively related to the distance from the major international port Hai Phong.[18] Regression results are shown in Appendix Table A1. The impact of the distance from the port on foreign firms is statistically significant when we exclude firms in Hanoi, as foreign firms are likely to be attracted to the political center. We also confirm that the exclusion of Hanoi does not alter our main finding of decaying spillover from the domestic core only for domestic firms. No such relationship is detected for private domestic firms, as most of them are too small to be direct exporters.[19] The significant relation found for SOEs is plausible as they are large in size, capital intensive, and subsidized by the government to export their products. This contrast suggests that the productivity of exporters is affected by the access to the major international port rather than to the domestic core market.

Second, although we cannot trace knowledge flows between firms, foreign firms can receive knowledge spillover from foreign parent firms, probably located in advanced countries, and employ superior production technologies and/or management know-hows. Hence, either through demand channel or knowledge channel, foreign firms are likely to be less influenced by domestic agglomeration. Although no direct tests for these interpretations are readily available within our limited data, the finding of such a difference between foreign firms and domestic firms in spillover of agglomeration should be worthwhile.

As another important finding from Table II.3, the significant border effect is detected only among private firms. The observation of the significant border effect, still powerful even

[17] Exporters or importers are not identified in Vietnamese Enterprise Survey. No previous research on Vietnam has used micro-data on trade. McCaig (2011) constructs province-level tariffs from industry-level tariffs weighted by regional employment shares. Brambilla et al. (2012) use the share of fishing income in total household income to analyze U.S. antidumping duty on catfish.

[18] The other large port is located in or near Ho Chi Minh. The distance from the northern border with China is almost automatically inversely related to the distance from Ho Chi Minh.

[19] McCaig and Pavcnik (2014) find that employment shifts away from household business toward registered enterprises especially in provinces nearer to the major ports.

after four decades since the reunification, is driven not by state-owned or foreign-owned firms. As virtually all foreign firms are established only recently, no effect of former border on foreign firms is as expected. Following the policy and central planning by the national government, SOEs are likely to choose production technologies or management practices irrespective of the former border. In other words, such a persistent border effect may be rooted not in exogenous regulations or public policies but probably in private business transactions, customs or culture, often intertwined with natural geography. As displayed in the lower part of Table II.3, we also confirm such persistent border effect only for private domestic firms even if the binary dummy *North* is without interacting with *DistB*. We also confirm that our main findings are virtually unaltered even if the firms in Hanoi, the national capital, or in Da Nang, the largest city in the central region of the country, are excluded from the sample.[20]

This effect of distance interacted with the border suggests that agglomeration spillover decays more seriously after crossing the former border possibly due to barriers in knowledge spillover, or in matching or learning. The institutional difference across the former border may interact with physical distance and dilute the spillover of agglomeration externality to remote locations, or alternatively northern regions near the former border has become assimilated with southern regions through relatively active interactions with firms in the South and receive more benefit from agglomeration. As a related finding of the effect of the distance from the border, Redding and Strum (2008) discover that West German cities closer to the East-West German border experienced a substantial decline in population growth after the division of Germany.

To explore the underlying determinants for such persistent North-South gap, we need to carefully collect more detailed data, for example, on regional characteristics. As Alesina and Fuchs-Schündeln (2007) find in the German case, preference of people and/or fundamental

[20] Estimation results from these limited samples are available upon request.

behaviors of workers and managers might have changed under contrasting regimes for three decades of North-South division. Exchanges of goods and services might be relatively inactive across the former border even after long years since reunification, as Felbermayr and Gröschl (2014) report that the North-South border during the Civil War lowers current commodity flows by around 13% in the U.S. The analysis along this line in depth is left for future work, but our preliminary regressions suggest that actual geography, such as heavy costs of transports or travels in mountain areas compared with flat areas along a navigable river, might affect the speed of spatial attenuation of spillovers.[21]

### *4.3. Cross-regional impacts*

Although our main focus of this paper is examining whether the spatial attenuation of agglomeration spillover is affected by the national border or corporate ownership, this section considers spillovers from regions other than the core or own province. As the previous section shows that the productivity of foreign firms is not affected by domestic agglomeration or former border, we need to explore geographic determinants of productivity for any type of firms, especially for foreign firms. For this purpose, we expand our scope from the sole focus on Ho Chi Minh to the inclusion of all regions in this country. To capture the effects of surrounding regions, we first introduce the market potential *MP* as in Harris (1954) by

$$MP_r \equiv \sum_q \frac{GDP_q}{D_{rq}} \tag{3}$$

where $D_{rq}$ is geographical distance between capitals of provinces $r$ and $q$. This index is a weighted average of regional GDP summed over all provinces with inverse distance as the weight. While market potential has been intensively examined in its impact on wage or firm

[21] Appendix Table A2 reports the regression results with region dummies, where Vietnam is divided into six broadly defined regions. We find that the negative effect of the distance from the core is particularly large for private firms in Region 2, which is the mountain area in the North.

location, the estimation of its impact on firm-level productivity has been so far limited.[22] As in the previous regressions, GDP of own region is weighted by the inverse of the internal distance. We replace the distance from Ho Chi Minh City and GDP of the own region in (2) by this market potential variable as follows.

$$\ln Q_{ijr} = \alpha_0 + \alpha_1 \ln K_j + \alpha_2 \ln L_j + \lambda_1 \ln MP_r + \lambda_2 North_r + \delta \cdot IND_i + v_{ijr} . \quad (4)$$

As GDP of own region is merged with all other regions, we treat market potential as exogenous for each firm. To capture the border effect, we introduce the binary dummy *North*, which takes the value one for firms locating north of the 17-degree latitude and zero for those in the former South Vietnam. The error term is denoted *v*. We estimate (4) with firm type dummies or separately for different types of firms. We expect the coefficient on *MP* be positive.

Although *MP* is defined based on regional GDP, the productivity of a firm may be influenced by the mere presence of other firms. Henderson (2003) shows that high productivity in agglomerated regions is due to the presence of other firms *per se* rather than their large size of production/employment. As firms "could be interpreted as a separate source of information spillovers" (Henderson 2003: p.18), the count (rather than the size) of such sources should be related with externality. To capture this effect, following Crozet et al. (2004), we next introduce an alternative measure of spillovers from surrounding regions in terms of the number of firms:

$$NP_r \equiv \sum_q \frac{\#Firms_q}{D_{rq}} . \quad (5)$$

[22] Head and Mayer (2004) find a significant impact of market potential on locations of Japanese affiliates in Europe. Ottaviano and Pinelli (2006) find the strong effect of market potential on productivity at the region level, not firm level in Finland. To estimate the impact of university location on regional productivity in Sweden, Andersson et al. (2004) construct a weighted average of the number of students and researchers of each region with inverse distance as weights and detect spillovers at the municipality-level.

The number of firms in each province is expressed by *#Firms*.[23] The coefficient on *NP* is expected positive.

Table II.4 reports the results with market potential *MP*, while Table II.5 presents the results with the presence of other firms *NP*. The binary dummy *North* and industry dummies are included in both cases. As the results in these two tables are similar, we discuss them combined.

As the most important finding from these tables, the spillover from all the regions, either measured in *MP* or *NP*, are significantly positively related to the productivity of all types of firms. Firms located in regions surrounded by larger markets or larger number of other firms tend to be more productive. We also find that the magnitude of its impact, or the elasticity of productivity with respect to *MP* or *NP*, appears the largest for foreign-owned firms. Combined with our previous results on the agglomeration spillovers from the domestic core, the productivity of foreign firms is likely to be influenced more by demand or the presence of other firms in surrounding locations. From the same tables, we find that the border effect is statistically significant only for domestic firms, not for foreign firms.

This finding of the significantly positive impact of market potential on firm-level productivity is consistent with previous results, such as the case of Spain by Holl (2012). In a study of a similar historical natural experiment, Wolf (2007) also finds the significant impact of market potential on industrial reallocations after the reunification of Poland in the early twentieth century.

**5. Concluding remarks**

The use of firm-level data in Vietnam enables us to examine how the spatial decay of agglomeration externality with distance is affected by historical, institutional or organizational factors. The investigation of Vietnam is suitable for this research purpose, since the country experienced the division into North and South and then reunification in the past century, and

[23] As in *MP*, we include firms in the same region discounted by the average internal distance.

is now reforming and liberalizing its socialist economy by initiating Doi Moi and by joining WTO and TPP. We have actually found the persistent effect of the former national border on spatial attenuation of agglomeration spillovers even after four decades since the reunification among domestic firms, especially private domestic firms. Historical data on population at the province level at 1943 are used as an instrumental variable for local GDP. Such a persistent border effect among private firms appears not to be directed by public policy but instead rooted in perceptions of residents or influenced by actual geography, which is beyond our analysis. The productivity of firms, including foreign-owned firms, is sensitive to the market potential and to the concentration of other firms.

While these findings are informative for understanding the role of history and institution in agglomeration in particular or in economic geography in general, there still remain several important issues. For example, tracing dynamic entry and exit patterns of firms will help us discuss causality direction. Distributional information of firm productivity, including dispersion or skewness as examined by Okubo and Tomiura (2014) in the Japanese case, will reveal additional richer regularities for discussing agglomeration.

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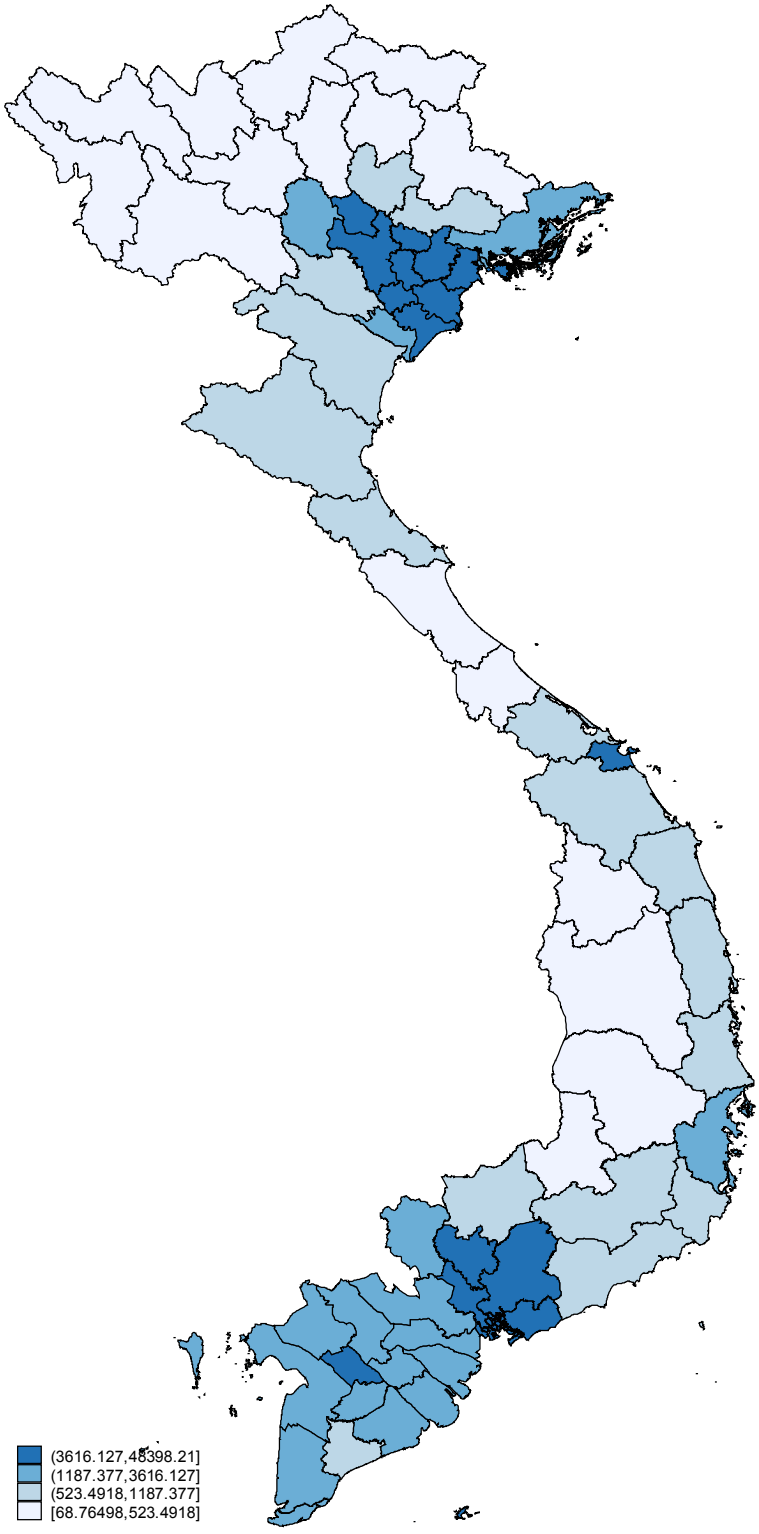
**Figure II.1: GDP of provinces**




Note: GDP per square kilometers at 2006 is shown. Truong Sa and Hoang Sa islands are omitted.

**Table II.1: Summary statistics**

| | #Obs. | Average | St. Dev | Min | Max |
|---|---|---|---|---|---|
| *Q All* | 119,134 | 23 | 409 | 0.001 | 80,800 |
| *SOE* | 3,530 | 269 | 1,756 | 0.001 | 62,000 |
| *Private* | 111,573 | 10 | 72 | 0.001 | 15,000 |
| *Foreign* | 4,031 | 155 | 1,426 | 0.001 | 80,800 |
| *L All* | 119,134 | 53 | 435 | 1 | 87,225 |
| *SOE* | 3,530 | 483 | 1869 | 1 | 87,225 |
| *Private* | 111573 | 29 | 128 | 1 | 10,059 |
| *Foreign* | 4,031 | 358 | 1347 | 1 | 55,468 |
| *K All* | 119,134 | 11 | 560 | 0.001 | 154,000 |
| *SOE* | 3,530 | 199 | 3147 | 0.002 | 154,000 |
| *Private* | 111573 | 3 | 78 | 0.001 | 21,000 |
| *Foreign* | 4,031 | 85 | 636 | 0.002 | 24,100 |
| *North* | 118,507 | 0.40 | 0.49 | 0.00 | 1.00 |
| *DistHCM* | 59 | 1,006 | 752 | 17 | 2,111 |
| *DistB*North* | 28 | 630 | 205 | 109 | 1,041 |
| *Dist Hai Phong* | 59 | 915 | 727 | 15 | 2,012 |
| *Local GDP* | 59 | 9.1 | 14.3 | 0.8 | 101.0 |
| *Pop1943* | 59 | 383 | 333 | 5 | 1,294 |
| *BOMB* | 59 | 29 | 50 | 0.01 | 335 |
| *MP* | 59 | 2.2 | 1.5 | 0.6 | 8.6 |
| *#Firms* | 59 | 2,019 | 4,843 | 240 | 32,482 |
| *NP* | 59 | 520 | 394 | 158 | 2,319 |

Notes: Production (Q), capital (K), and GDP are in billion VND. The population is in thousand people. Distance is in kilometers.

**Table II.2: Basic regressions**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *L* | 0.670*** | 0.699*** | 0.699*** | 0.700*** | 0.700*** |
| | (0.0309) | (0.0284) | (0.0285) | (0.0292) | (0.0292) |
| *K* | 0.270*** | 0.270*** | 0.270*** | 0.271*** | 0.271*** |
| | (0.00611) | (0.00662) | (0.00661) | (0.00630) | (0.00631) |
| *Dist HCM* | -------- | −0.0988*** | −0.100*** | −0.00909 | −0.0139 |
| | | (0.0234) | (0.0233) | (0.0343) | (0.0337) |
| *DistB* North* | -------- | −0.0345** | -------- | −0.0687*** | -------- |
| | | (0.0168) | | (0.0199) | |
| *North DUM* | -------- | -------- | −0.212** | -------- | −0.419*** |
| | | | (0.105) | | (0.123) |
| *Local GDP* | -------- | -------- | -------- | 0.114*** | 0.111*** |
| | | | | (0.0224) | (0.0227) |
| # Firms | 119,134 | 118,507 | 118,507 | 118,507 | 118,507 |
| $R^2$ | 0.629 | 0.653 | 0.653 | 0.655 | 0.655 |

Notes: The dependent variable is the firm's production. All the variables, except dummies, are in logarithms. Industry dummies, firm type dummies and the constant term are included in all cases but omitted from the table. Standard errors clustered at the province level are shown in parentheses. Statistical significance is denoted by asterisks: *** at 1%, ** at 5%, and * at 10%.

**Table II.3: IV results disaggregated by ownership types**

| | (1)<br>All firms | (2)<br>Private | (3)<br>SOE | (4)<br>Foreign |
|---|---|---|---|---|
| *L* | 0.724*** | 0.684*** | 0.870*** | 0.850*** |
| | (0.0292) | (0.0308) | (0.0286) | (0.0313) |
| *K* | 0.281*** | 0.265*** | 0.256*** | 0.307*** |
| | (0.00622) | (0.00753) | (0.0153) | (0.0335) |
| *Dist HCM* | −0.0983*** | −0.0964*** | −0.110*** | −0.0815* |
| | (0.0279) | (0.0290) | (0.0159) | (0.0435) |
| *DistB* North* | −0.0360** | −0.0376** | −0.0164 | 0.0153 |
| | (0.0173) | (0.0180) | (0.0120) | (0.0286) |
| *Local GDP* | 0.105*** | 0.0917*** | 0.127*** | 0.148** |
| | (0.0314) | (0.0310) | (0.0414) | (0.0703) |
| # Firms | 118,507 | 110,979 | 3,500 | 4,028 |
| $R^2$ | 0.653 | 0.608 | 0.762 | 0.671 |

| | (1)<br>All firms | (2)<br>Private | (3)<br>SOE | (4)<br>Foreign |
|---|---|---|---|---|
| *L* | 0.723*** | 0.684*** | 0.870*** | 0.851*** |
| | (0.0292) | (0.0308) | (0.0287) | (0.0312) |
| *K* | 0.281*** | 0.265*** | 0.256*** | 0.307*** |
| | (0.00624) | (0.00754) | (0.0153) | (0.0334) |
| *Dist HCM* | −0.0997*** | −0.0979*** | −0.107*** | −0.0838* |
| | (0.0277) | (0.0288) | (0.0164) | (0.0435) |
| *North DUM* | −0.222** | −0.231** | −0.116 | 0.107 |
| | (0.108) | (0.112) | (0.0778) | (0.182) |
| *Local GDP* | 0.0989*** | 0.0848*** | 0.126*** | 0.152** |
| | (0.0307) | (0.0304) | (0.0396) | (0.0695) |
| # Firms | 118,507 | 110,979 | 3,500 | 4,028 |
| $R^2$ | 0.652 | 0.608 | 0.762 | 0.671 |

Notes: The type of firms covered by each regression is shown in the top row of each column. Firm type dummies are added in the first column. The second-stage IV results are shown. Industry dummies and the constant term are included in all cases. All variables, except dummies, are in logarithms. Standard errors clustered at the province level are shown in parentheses.

**Table II.4: Market potential**

| | (1) Private | (2) SOE | (3) Foreign |
|---|---|---|---|
| *L* | 0.682*** | 0.869*** | 0.850*** |
| | (0.0304) | (0.0270) | (0.0317) |
| *K* | 0.265*** | 0.256*** | 0.307*** |
| | (0.00755) | (0.0146) | (0.0343) |
| *MP* | 0.181*** | 0.235*** | 0.355*** |
| | (0.0383) | (0.0264) | (0.0829) |
| *North* | −0.441*** | −0.327*** | 0.118 |
| | (0.0553) | (0.0518) | (0.107) |
| # Firms | 110,979 | 3,500 | 4,028 |
| $R^2$ | 0.608 | 0.763 | 0.672 |

Notes: Industry dummies and the constant term are included in all cases. All variables including *MP*, except dummies, are in logarithms. Standard errors are clustered at the province level.

**Table II.5: Presence of other firms**

| | (1) Private | (2) SOE | (3) Foreign |
|---|---|---|---|
| *L* | 0.681*** | 0.867*** | 0.850*** |
| | (0.0305) | (0.0272) | (0.0317) |
| *K* | 0.266*** | 0.257*** | 0.309*** |
| | (0.00767) | (0.0147) | (0.0346) |
| *NP* | 0.138*** | 0.199*** | 0.313*** |
| | (0.0327) | (0.0259) | (0.0699) |
| *North* | −0.499*** | −0.389*** | 0.0236 |
| | (0.0515) | (0.0482) | (0.0750) |
| #Firms | 110,979 | 3,500 | 4,028 |
| $R^2$ | 0.607 | 0.763 | 0.673 |

Notes: See notes to Table II.4.

Appendix

**Table A1: Distance from the major international port**

| | (1) Private | (2) SOE | (3) Foreign | (4) Private | (5) SOE | (6) Foreign |
|---|---|---|---|---|---|---|
| *L* | 0.680*** | 0.870*** | 0.855*** | 0.653*** | 0.865*** | 0.842*** |
| | (0.0306) | (0.0289) | (0.0314) | (0.0175) | (0.0384) | (0.0319) |
| *K* | 0.266*** | 0.259*** | 0.301*** | 0.273*** | 0.257*** | 0.296*** |
| | (0.00788) | (0.0152) | (0.0330) | (0.00854) | (0.0213) | (0.0365) |
| *Dist Hai Phong* | −0.0178 | −0.0819*** | −0.0561 | −0.0210 | −0.0826** | −0.127*** |
| | (0.0830) | (0.0268) | (0.0559) | (0.0860) | (0.0349) | (0.0467) |
| *South* | 0.592*** | 0.620*** | 0.310 | 0.613*** | 0.702*** | 0.681*** |
| | (0.213) | (0.110) | (0.222) | (0.214) | (0.126) | (0.209) |
| *Local GDP* | 0.104*** | 0.101** | 0.122** | 0.0965*** | 0.0853* | 0.101* |
| | (0.0228) | (0.0378) | (0.0516) | (0.0249) | (0.0448) | (0.0531) |
| Regional coverage | All | All | All | Excluding Hanoi | Excluding Hanoi | Excluding Hanoi |
| # Firms | 110,979 | 3,500 | 4,028 | 91,245 | 2,754 | 3,572 |
| $R^2$ | 0.606 | 0.760 | 0.670 | 0.606 | 0.767 | 0.668 |

Notes: IV results at the second stage are shown. *South* is the binary dummy for firms in the south. Industry dummies and the constant term are included. Standard errors are clustered at the province level.

**Table A2: Variations across regional blocks**

| | (1)<br>Private | (2)<br>SOE | (3)<br>Foreign |
|---|---|---|---|
| *L* | 0.694*** | 0.868*** | 0.854*** |
| | (0.0311) | (0.0274) | (0.0300) |
| *K* | 0.262*** | 0.254*** | 0.299*** |
| | (0.00674) | (0.0143) | (0.0323) |
| *DistHCM* | −0.0110 | −0.110*** | −0.00661 |
| | (0.0322) | (0.0280) | (0.0419) |
| *DistHCM*R1* | −0.0718*** | 0.00160 | −0.0147 |
| | (0.0201) | (0.0148) | (0.0222) |
| *DistHCM*R2* | −0.126*** | −0.0442** | −0.120*** |
| | (0.0211) | (0.0175) | (0.0283) |
| *DistHCM*R3* | −0.0717*** | −0.0227* | −0.0504** |
| | (0.0183) | (0.0128) | (0.0242) |
| *DistHCM*R4* | −0.0503** | −0.0119 | −0.200*** |
| | (0.0208) | (0.0242) | (0.0471) |
| *DistHCM*R6* | 0.00698 | 0.0408** | −0.0179 |
| | (0.0185) | (0.0169) | (0.0237) |
| *Local GDP* | 0.0783*** | 0.0834** | 0.183*** |
| | (0.0285) | (0.0355) | (0.0411) |
| # Firms | 111,573 | 3,530 | 4,031 |
| $R^2$ | 0.613 | 0.764 | 0.676 |

Notes: Regional dummies are denoted by *R1, R2*,…, and *R6*. The second-stage IV results are shown. Industry dummies are included in all cases. See also notes to Table II.3. Vietnam is divided into the following six regions:

R1: Red river delta: Ha Noi, Ha Tay, Vinh Phuc, Bac Ninh, Quang Ninh, Hai Duong, Hai Phong, Hung Yen, Thai Binh, Ha Nam, Nam Dinh, Ninh Binh.

R2: Northern midlands and mountainous: Ha Giang, Cao Bang, Bac Kan, Tuyen Quang, Lao Cai, Yen Bai, Thai Nguyen, Lang Son, Bac Giang, Phu Tho, Dien Bien, Lai Chau, Son La, Hoa Binh.

R3: North Central and South Central Coast: Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien - Hue, Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Ninh Thuan, Binh Thuan.

R4: Highlands: Kon Tum, Gia Lai, Dak Lak, Dak Nong, Lam Dong.

R5: South East: Binh Phuoc,Tay Ninh, Binh Duong, Dong Nai, Ba Ria Vung Tau, Ho Chi Minh.

R6: Mekong Delta: Long An,Tien Giang, Ben Tre,Tra Vinh,Vinh Long,Dong Thap,An Giang, Kien Giang, Can Tho, Hau Giang, Soc Trang, Bac Lieu, Ca Mau.

# CHAPTER 3

# SHORT-TERM AND LONG-TERM IMPACT OF WAR ON THE ECONOMIC PERFORMANCE:

# EVIDENCE FROM VIETNAM

2nd December 2016


## Abstract

Based on the rich historical population and other economic data at province-level in Vietnam, I confirm that the short-term impact of war on the economic performance is highly statistically significant and differs among North, South and Middle region provinces. In the long-run, the war has not shown significant or negative impact on the concentration of firm or the wealth of provinces. Zipf slopes, DID method, time-series data as well as cross-section data are used in this research.



Keyword: war, bombing, density, population, concentration, province-level data, Zipf, DID

## 1. Introduction

Vietnam has a long history of war like many countries that have the location beside the beach which have the advantage in sea transportation and are near the equator in the Northern Hemisphere of Earth where is targets of invasion from other bigger countries. The countries in the North often are stronger and have male characteristic and make war while countries in the South with female characteristics are always countries are invaded. In this case, Vietnam was invaded by China for many years until the 11th century with many kings as well as changes in the territory, before becoming an independent country. After escaping the domination of China, Vietnam also experienced a lot of ups and downs with the civil war split the country into 2 regions such as North and South or 3 regions including North, Central, and South until the end of the 19th century when the first time French shot South of Vietnam in 1858. In this period, Vietnam had been divided into 3 regions. In 1945, the abdication of the last King Bao Dai has ended the feudal era that existed for thousands of years in Vietnam. At the same time, the Democratic Republic of Vietnam country was born which united 3 regions into an independent Vietnam country. The process of US intervention in Vietnam (1948-1975) is the evolution of a series of policies and measures of political, diplomatic and military to fulfill their objectives in Indochina region (where Vietnam is the main focus). This process is considered to be the direct cause leading to a prolongation of the Indochina War and was the spark for the Vietnam War ensued. The US role has slowly gone from aid, adviser to the direct military intervention. In the time of "War against the US"[24], this country split again into 2 regions which are North and South from 1954-1975 before the unification to become the Republic of Socialist Vietnam until now.

[24] Some people feel that the name War against the US is not neutral because of there were Vietnamese who fought on the same side with the United States. Some argue that the Vietnam War name shows the Westerners' view rather than Vietnamese. However, in terms of academics, scholars and authors of books and journals outside of Vietnam often use the name "Vietnam War" because of its international nature. In this research, the Vietnam War or War against the US is used with the same meaning.

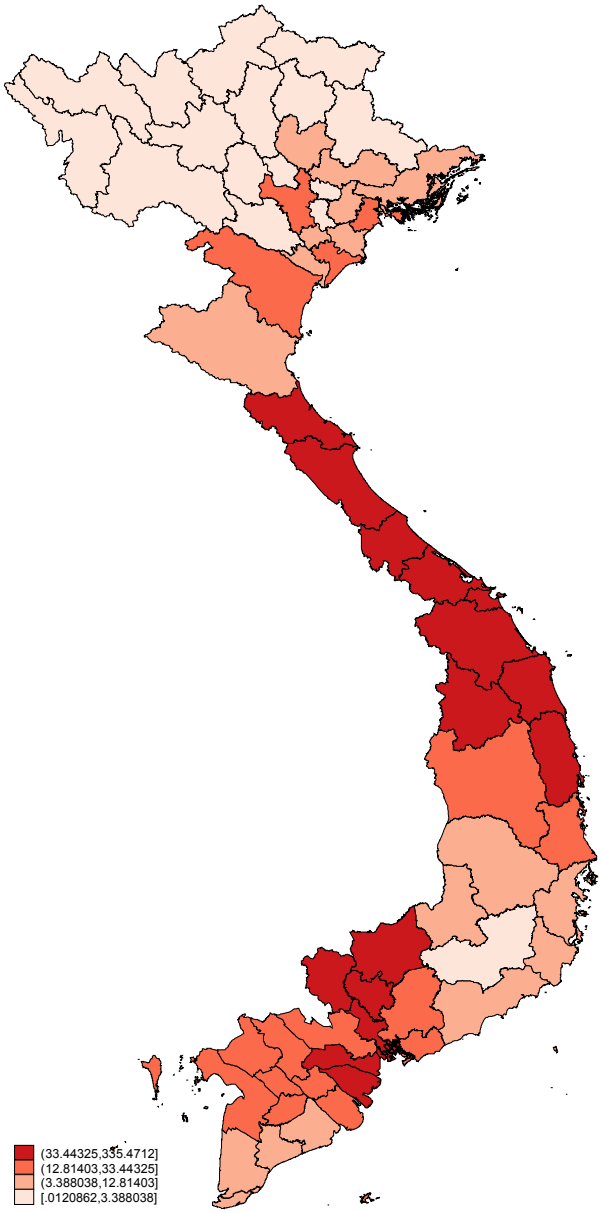
During the time of division from 1954 to 1975, US had been long and heavy bombing to the center of Vietnam. In the history of world wars, Vietnam is the country which has the most bombs thrown. US bombs dropped on Vietnam are nearly 3 times of total bomb used in the First World War II, the so-called "lunarization" policy, and about fifteen times total tonnage in the Korean War. In the years from 1966 to 1968, the US and allied aircraft threw 2,865,808 tons of bombs on Vietnam, Laos, and Cambodia. Until 1975, the US military has thrown seven million tons of bombs and artillery shells into North and South of Vietnam. The war ended, but the country has about 66,000 km2 unexplored bombs and mines. An estimated of 600,000 tons of unexplored mine underground or scattered across the country, especially the provinces of Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien - Hue, Quang Nam, and Quang Ngai ... The mine was removed only by about 20%. On average, each year there are about 20,000 hectares of land cleaned. With this progress, it will take about 300 years to eliminate all kinds of unexploded bombs. Landmines left from the war continue to cause heavy losses of life, property and the lives of people. 10,529 people were killed, and 12,231 people of whom 25% are children ages 14 and younger were injured by this landmine which severely affects economic development and society.

The map of bomb density shows where the most serious bombing places in Vietnam are. From the map, the provinces in the Center Region such as Quang Binh, Quang Tri, Thua Thien Hue have the heaviest bomb density.

The question for this research is whether there are short-term and long-term impacts of US bombing on Vietnamese economic performance. Actually, there were much of research on this topic such as research of Miguel and Roland (2011) show no negative impacts on local poverty, consumption, infrastructure, literacy or population density. However, measure both temporary and long-term impacts at the same time with historical rich-data under both cross section at province level and time series format of data is not considered in any research.

Moreover, this research has not only population data as a proxy of economic performance in the past but also has some other economic indicators at province level in the past like area of paddy, the productivity of paddy, the number of hospital and bed in the hospital for both regions in division period. This research also is different with research of Miguel and Roland (2011) which has a number of firms, a number of labors or GDP at province level as dependent variables. To make the data for this research, authors need a lot of labor-intensive effort for this paper which is present more detail in the data description part. Methodology and measurement which are used in this paper are OLS, DID, Zipf law of population, and regressions for time series data.

The structure of this research is as follow: coming after the introduction part, the section 2 is literature review which introduces some most impact papers in the field of the effect of war on economic growth. Section 3 continues with data description while section 4 introduces the framework for the empirical analysis of the long-term impact of war as well as the results and analysis. The short-term impact is measured in section 5 with time series data and Zipf law. The conclusion is presented in the section 6.




**Map 1 : Total US bombs per km2 by province in Vietnam from 1965-1975**

## 2. Literature review

There are two aspects of the research topic that examines the impact of war on the economy including long-run impacts and short-term. This section describes the literatures about these two trends.

Many authors consider the long-run impact of war on the economic development, education or other social life quality. Some researches show the positive impact, some other shows the negative impact and some shows not significant relationship. One of the most popular research about this topic is the Miguel and Roland (2011) has investigated the impact of U.S. bombing in Vietnam. The dependent variable they used is local poverty rates, consumption levels, infrastructure, literacy, and population density through 2002. In the period from 1965 to 1975, Vietnam suffered the most intense bombing campaign in military history and had massive humanitarian costs. With unique U.S. military dataset containing bombing intensity at the district and province level, they have examined the damage of war led to the local poverty trap that using an instrumental variable approach. The result shows no negative impacts of U.S. bombing on the local poverty even this is the heaviest bombing in human history.

Another research about this topic is research of Che, Du, Lu, and Tao (2015) about the long-term impact of conflicts between countries on cross-border trade and investment with the case of Japan and China due to the Japanese invasion. The research shows the historical animosity still influences the international trade and investment despite the globalized world. The data of civilian casualties in Chinese regions is proxy of war damage and use difference-in-differences estimation to measure the long-run impacts of the war. Their study finds that the regions with larger war casualties have attracted less investment from Japan and engaged in less trade with Japan. Therefore, the historical animosity still matters in international trade and investment.

Considering the labor economic aspect, the research of Ichino and Winter -Ebmer (2004) finds that in the World War II, children in Europe were significantly less likely to proceed in to higher education. This research also estimate the earning losses implied the loss of GDP for their country suffered by those people who did not receive the higher education because of the war. Instrument Variable estimates is use as measures of the Local Average Treatment Effects of education.

Unlike above researches, Davis and Weinstein (2002) use a very rich population data from Stone Age to the modern era to investigate the distribution of economic activity within a country according to three theories: increasing returns, random growth and locational fundamentals. Their research confirms that long-run city size is robust even to large temporary shocks.

Short-term impact of war has been discussed in the research of Redding, Sturm, and Wolf (2011). The question in this research is whether the industry location is determined by fundamentals or a shift between multiple steady-states. Using the case of Germany where is divided after Second World War and has a reunion after that as the exogenous shock to industry location, this paper provides evidence that the relocation of Germany's air hub from Berlin to Frankfurt is a shift between multiple steady-states. The model is used in this research allows changes in trends and intercepts of airport passengers shares for each airport during the prewar, division and reunification periods. Moreover, difference-in-differences estimations are introduced to examine how the division effect on the location of Germany's leading airport. In a similar way, my paper does the same method to see how the population of Vietnamese provinces change through three periods including union, division, and reunion as presented in the next sections. A slightly different motivation in the research of Redding and Sturm (2008) has confirmed the importance of market access for economic development. The theory framework of this research is two agglomeration forces are "home market effect" and

"cost of living effect" and dispersion forces are "market crowding effect" and "congestion effect". The empirical specification tries to measure the impact of the border as treatment group of cities and co-interaction term border*division on the population growth of cities. The results show that division's negative impact on cities close to the East-West German border through market access. In the common voice, research of Nakajima (2008) in case of Japan confirms that the cities located close to Korea suffered greater division shock because of the decline in market access. Population growth rates of border cities declined significantly from 1950 to 1970.

In this paper, we combine three papers those are Davis and Weinstein (2002), Redding et al. (2011) and Miguel and Roland (2011) to find both short-term and long-term impact of war on the distribution of firm as well as the economic performance of provinces in Vietnam with unique historical population data from 1921 until now.

**3. Data description**

To make the cross-section and time-series data, I have done a huge labor intensive job to aggregate data into a consistent package. Moreover, I have merged data form two main databases including Vietnamese Enterprise Census and Vietnamese Population Census. This section describes how I get the data, the source of data, the data types and description of data.

***3.1 Population data aggregation methodology***

Due to the change of provinces area and name along history, data of population has been aggregated into 40 provinces in general. This data had been separated to several periods that depends on the division and reunion time and the change of policy of Vietnam. The oldest data is from 1921-1953 where there are 72 provinces. Second period is from 1954 to 1975 with about 70-78 provinces but the names of provinces change widely compare to previous period because from 1954 Vietnam is divided into two regions North of Vietnam and South of Vietnam. There were two separated governments at that time. The third periods with only 40

provinces is from 1976 to 1984 after the reunion of North and South of Vietnam and US army withdrew back to home country. This provinces merging was made because the management purpose of government as well as the lack of labor force to handle more than 70 provinces as before. The number of provinces increased through later periods such as 1985, 1990-2003 and 2004-2007 are 52, 61 and 64 provinces consequently. From 2008 Hanoi was expanded and there are 63 provinces until recent. The name and the way to combine data are shown in appendix 1. The source of population data is extracted from the series of book namely "Vietnam statistical data in the 20th century" which is published by General Statistics Office of Vietnam. The series include 6 parts divided into 3 books with total about 5000 pages. The first book is Vietnam statistical data from 1901 to 1975 which has three part (Vietnam statistical data from 1901-1954, and statistics of North of Vietnam from 1955 to 1975, and statistics of South of Vietnam from 1955-1975). This is the most valuable source of historical data among three books and many of them are published for the first time which become useful for researcher about Vietnam. The second database is for the period from 1976 to 2000 and the third book is about "21 statistical large-scale surveys and censuses in the 20th century".

Beside population data, other data can be good candidates for economic performance also available in 1954-1975 such as of agricultural, forestry, health and transportation industries at province level. I have data of population from 1921 until 1953 to be the proxy of economic development of each province. From 1954, the data was divided into two regions that are North and South. For example, the data of agriculture industry in the North in this period includes the number of agriculture co-operative societies (which is "hợp tác xã" in Vietnamese), the number of generator and working machines; planted area or productivity or yield of food crops, paddy, maize, sweet potatoes, cassava for both season and Spring and winter season separately; the number of buffaloes, cattle, pigs that is produced or supplied to the State. In addition, forestry, health, and transportation related statistics also recorded in the

books. At the same time, the statistics for the South of Vietnam are quite similar with the North. Finally, I got some common indicators for the whole country in this division period which are the paddy area, paddy productivity, the number of hospital and number of hospital beds by the province for some years as presented in the statistics summary table III.1.

I have taken the data of the number of firms, the number of labors from the Vietnamese Firm Surveys in 2006. This data and area data has is 64 observations in province-level, while the bomb data from research of Miguel and Roland (2011) has data of 61 provinces-level observation. This database includes district-level bomb data as well from 1965 to 1975. To merge them with population data, all statistics are downsized to 40 province-level observations.

***3.2 Database types***

This research uses two types of the database to measure both short-run and long-run impacts of bombing into Vietnam. The first database is cross-section data for measuring the long-run impact while the time-series data is used to investigate the short-run impact. To make these databases consistently, data are aggregated downsize to 40 provinces as the biggest number of observations. All the changes of each province in $20^{th}$ century such as names changing, expanding and narrowing is taken into consideration with a lot of effort. The aggregation coding method for provinces is presented in appendix 1 that have the basic year is 1976-1884 when the number of the province is lowest. Provinces of all other years are merged under the same names with provinces in this period.

***3.3 Data descriptions***

The summary statistic table III.1 describes the number of observations, mean, standard deviation, min and max values of number of firm and labor, area, GDP, bomb, population, agriculture and health of the cross-section data. The number of firms and labors at each province is data in the year 2006 because this time are not affected by the economic crisis

from 2008. From this table, the mean value of firm number is 2978 firms and of labor is 159 thousand labors. The data are divided into three groups including State-Owned Enterprises (SOE), private enterprises (NonSOE), Foreign Direct Investment Enterprises (FDI). Among this three groups, the most populous is private firms with more than 111 thousand enterprises in total and they also create biggest number of labor for the economy with more than three million labors. The number of FDI firm is bigger than the number of SOE firm but the SOE firms provide more job opportunities than the FDI firms. In some provinces, there is no FDI firm such as Ha Tuyen province, Cao Bang province which are the North provinces and An Giang province located in the South. The city that has largest number of firm is Ho Chi Minh City.

The mean value of area of provinces is 7,723 square km with min value is 920 that is Hanoi Capital before enlargement in 2008. Each province has average number of GDP that is 14 trillion VND while the richest city in terms of this value also is Hochiminh City. The provinces in mountain region such as Cao Bang always are the poorest place.

The mean value of population for each province ranges from 390 thousand people in 1921 to 1343 thousand people in 1980. This table does not describe the population statistics for later years but they are available in the cross-section data. The area of planted paddy does not have big change through 1960 to 1973 but the productivity of paddy was much higher in 1973. The total number of hospital in 1968 was 390 hospital with 37,999 hospital beds while the average hospital is around 10 to 11 ones but the average hospital beds was much larger in 1973. Missing value error appears with zero value in some province there is no FDI firms or population or planted area. To make the zero value not become missing after taking logarithm, $10^{-10}$ are added in the number for all provinces before doing the logarithm calculation to solve the missing problem.

**Table III.1: Data description**

| Variables | Number of Provinces | Total | Mean | Sd | Min | Max |
|---|---|---|---|---|---|---|
| Number of firms | 40 | 119,134 | 2,978 | 5,610 | 346 | 32,482 |
| Number of SOE firms | 40 | 3,531 | 88 | 118 | 22 | 672 |
| Number of NonSOE firms | 40 | 111,574 | 2,789 | 5,313 | 310 | 30,816 |
| Number of FDI firms | 40 | 4,029 | 101 | 247 | - | 1,218 |
| Total labor (thousand labors) | 40 | 6,346 | 159 | 284 | 14 | 1,485 |
| Number of SOE labors (thousand labors) | 40 | 1,705 | 43 | 94 | 4 | 561 |
| Number of NonSOE labors (thousand labors) | 40 | 3,201 | 80 | 140 | 9 | 831 |
| Number of FDI labors (thousand labors) | 40 | 1,440 | 36 | 88 | - | 407 |
| Area of provinces (square km) | 40 | 308,991 | 7,723 | 5,783 | 920 | 25,110 |
| GDP of province in 2006 (trillion VND) | 40 | 538 | 14 | 16 | 2 | 101 |
| Total U.S. bombs, missiles, and rockets | 40 | 8,580 | 215 | 503 | 0 | 3,020 |
| Total U.S. bombs, missiles, and rockets per km2 | 40 | 1,746 | 44 | 92 | 0 | 558 |
| Population in 1921 (thousand people) | 40 | 15,584 | 390 | 360 | 1 | 1,531 |
| Population in 1931 (thousand people) | 40 | 17,681 | 442 | 394 | 5 | 1,826 |
| Population in 1936 (thousand people) | 40 | 18,952 | 474 | 415 | 7 | 1,901 |
| Population in 1943 (thousand people) | 40 | 22,615 | 565 | 509 | 5 | 2,235 |
| Population in 1960 (thousand people) | 40 | 29,989 | 750 | 554 | 1 | 2,054 |
| Population in 1965 (thousand people) | 40 | 33,449 | 836 | 609 | 52 | 2,411 |
| Population in 1968 (thousand people) | 40 | 35,612 | 890 | 645 | 73 | 2,777 |
| Population in 1974 (thousand people) | 40 | 44,476 | 1,112 | 764 | 123 | 3,665 |
| Population in 1976 (thousand people) | 40 | 49,160 | 1,229 | 786 | - | 3,602 |
| Population in 1977 (thousand people) | 40 | 50,413 | 1,260 | 782 | - | 3,506 |
| Population in 1978 (thousand people) | 40 | 51,421 | 1,286 | 765 | 87 | 3,471 |
| Population in 1979 (thousand people) | 40 | 52,462 | 1,312 | 793 | 91 | 3,397 |
| Population in 1980 (thousand people) | 40 | 53,722 | 1,343 | 804 | 93 | 3,376 |
| Area of Paddy planted in 1960 (thousand hectares) | 40 | 4,417 | 110 | 100 | - | 412 |
| Area of Paddy planted in 1965 (thousand hectares) | 40 | 4,828 | 121 | 98 | - | 398 |
| Area of Paddy planted in 1968 (thousand hectares) | 40 | 4,468 | 112 | 93 | - | 397 |
| Area of Paddy planted in 1973 (thousand hectares) | 40 | 4,915 | 123 | 105 | - | 483 |
| Paddy productivity in 1960 (thousand tons) | 40 | 8,958 | 224 | 204 | - | 915 |
| Paddy productivity 1965 (thousand tons) | 40 | 9,578 | 239 | 208 | - | 900 |
| Paddy productivity 1968 (thousand tons) | 40 | 8,064 | 202 | 177 | - | 847 |
| Paddy productivity 1973 (thousand tons) | 40 | 11,489 | 287 | 276 | - | 1,361 |
| Number of hospital in 1968 | 40 | 390 | 10 | 9 | - | 30 |
| Number of hospital in 1969 | 40 | 419 | 10 | 9 | 1 | 32 |
| Number of hospital in 1970 | 40 | 425 | 11 | 10 | 1 | 32 |
| Number of hospital in 1971 | 40 | 419 | 10 | 10 | 1 | 32 |
| Number of hospital in 1973 | 40 | 418 | 10 | 10 | 1 | 35 |
| Number of hospital beds in 1968 | 40 | 37,999 | 950 | 755 | 234 | 4,163 |
| Number of hospital beds in 1969 | 40 | 40,377 | 1,009 | 779 | 225 | 4,146 |
| Number of hospital beds in 1970 | 40 | 44,379 | 1,109 | 834 | 300 | 4,499 |
| Number of hospital beds in 1971 | 40 | 44,848 | 1,121 | 761 | 305 | 3,770 |
| Number of hospital beds in 1973 | 40 | 49,366 | 1,234 | 863 | 320 | 3,917 |

## 4. Framework to measure the short-run impact

### *4.1. Some basic indicators to measure the variation in regional density*

According to the research of Davis and Weinstein (2002), some of the measures of variation in regional density are presented in table III.2 and figure III.1. Even these measurements are

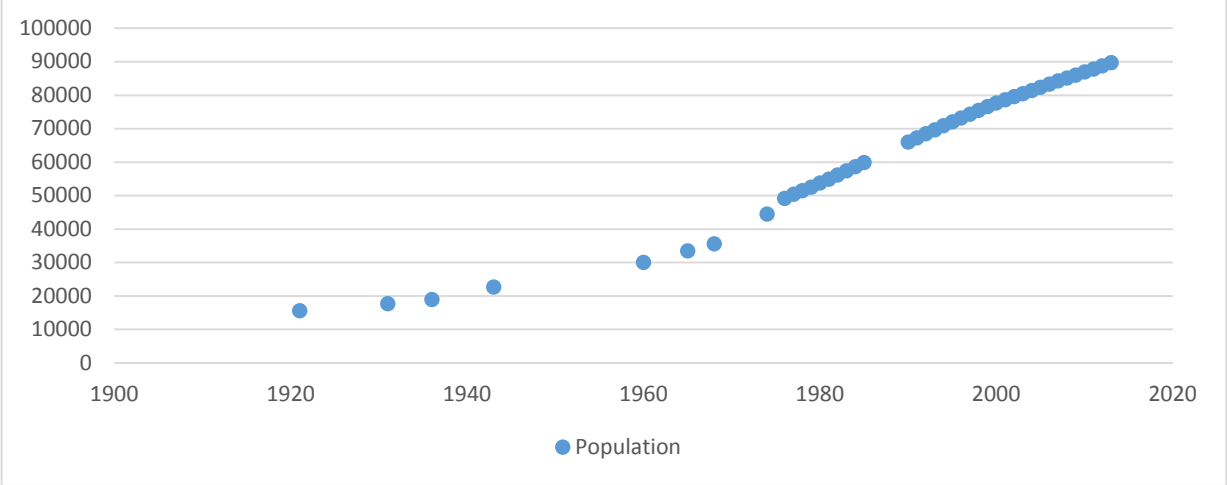



**Figure III.1: Population of Vietnam from 1921 until now (thousand people)**

simple but they contain rich information because they are the historical valuable data. The first indicator is the total population in thousand people unit of Vietnam through decades. The earliest year in this data is 1921 when Vietnam has only about 16 million people. The population number increases gradually through years. The growth speed in the peace periods after war 1975 until now is higher than the period before 1975 as showed in the figure III.1. In 2013, Vietnam has nearly 90 million people, stands in top 20 biggest countries in the World in terms of total population.

To measure the concentrations of population in some biggest cities, the second information is the percentage of the population of five largest regions to the total population. This number was quite high before the division and in the French Colonial period in Tonkin (North region) and Annam (Center region) and remained the emperors from Nguyen to Bao Dai (1926 to 1945). Before that, French already occupied Cochinchine (South region). The average values are around 35% in the five most populous regions. This number reduced in the division period from 1954-1975 to about 30 percent and reduce more in the reunion periods

after 1975 until with about 25%. From 2008 after enlarging of Hanoi, this proportion was bigger to about 29%.

The second indicator to see the variation of population density is the relative variance of log population density which is calculate by the ratio of variance of log of population density in year t and the variance of the log of population density in 2013. If this ratio is bigger than 1, it means that the population in the past time t varied greater than population in year 2013 and smaller than unity in the reverse case. In the case of Vietnam, all the case has this relative variance ratio greater than unity which means the population in the history change much higher than the modern time. This change can be explained by each period in the history. From 1921 to 1943 in the French Colonial period, the population fluctuated greatly with values are bigger than 2. In the division period, although this number smaller but it still bigger than 1. The biggest number is 13.9 in the year 1976 and 1977, this value maybe bias because at that time Vung Tau –Con Dao become one of the region of Dong Nai and population data for this period equal to zero. The variance of population density in the past time still bigger than present time until 1986 when Vietnam has "Doi Moi" program. Since then, these numbers almost are close to unity. This appears to reflect the fact that in the war time the population varied greatly.

One of measurement for regional density is the Zipf coefficient. This measure provides the variation in regional density through its slope. The variation of population density range from zero to minus infinity as the same way with the population were clustered in a single region to many regions. Research of Gabaix (1999) and Rosen and Resnick (1980) and Davis and Weinstein (2002) show most of cities or countries level Zipf slopes that close to minus unity which means the population density varies greatly.

**Table III.2: Variation of the Regional Density**

| Year | Population (thousand People) | Share of five largest regions | Relative variance of log population density | Zipf coefficient with raw population | Zipf coefficient with population density |
|---|---|---|---|---|---|
| 1921 | 15,584 | 35.5% | 2.7 | -0.572*** | -0.497*** |
| 1931 | 17,681 | 34.7% | 2.3 | -0.714*** | -0.573*** |
| 1936 | 18,952 | 34.6% | 2.1 | -0.750*** | -0.600*** |
| 1943 | 22,615 | 35.1% | 2.3 | -0.682*** | -0.554*** |
| 1960 | 29,989 | 30.0% | 2.3 | -0.516*** | -0.556*** |
| 1965 | 33,449 | 30.3% | 1.6 | -0.987*** | -0.728*** |
| 1968 | 35,612 | 30.5% | 1.5 | -1.082*** | -0.766*** |
| 1974 | 44,476 | 29.0% | 1.5 | -1.139*** | -0.766*** |
| 1976 | 49,160 | 28.4% | 13.9 | -0.0561* | -0.123*** |
| 1977 | 50,413 | 27.8% | 13.9 | -0.0554* | -0.123*** |
| 1978 | 51,421 | 27.3% | 1.4 | -1.118*** | -0.805*** |
| 1979 | 52,462 | 27.3% | 1.4 | -1.106*** | -0.797*** |
| 1980 | 53,722 | 27.1% | 1.4 | -1.107*** | -0.800*** |
| 1981 | 54,927 | 27.0% | 1.4 | -1.106*** | -0.803*** |
| 1982 | 56,170 | 26.9% | 1.4 | -1.112*** | -0.807*** |
| 1983 | 57,373 | 26.8% | 1.4 | -1.099*** | -0.807*** |
| 1984 | 58,653 | 26.7% | 1.4 | -1.109*** | -0.811*** |
| 1985 | 59,872 | 26.6% | 1.4 | -1.123*** | -0.818*** |
| 1990 | 66,017 | 25.8% | 1.1 | -1.576*** | -0.885*** |
| 1991 | 67,242 | 25.7% | 1.1 | -1.588*** | -0.891*** |
| 1992 | 68,450 | 25.7% | 1.1 | -1.599*** | -0.897*** |
| 1993 | 69,645 | 25.7% | 1.1 | -1.610*** | -0.904*** |
| 1994 | 70,825 | 25.6% | 1.1 | -1.619*** | -0.910*** |
| 1995 | 71,996 | 25.6% | 1.1 | -1.628*** | -0.917*** |
| 1996 | 73,157 | 25.5% | 1.1 | -1.637*** | -0.924*** |
| 1997 | 74,307 | 25.5% | 1.1 | -1.643*** | -0.930*** |
| 1998 | 75,456 | 25.4% | 1.0 | -1.649*** | -0.936*** |
| 1999 | 76,597 | 25.3% | 1.0 | -1.657*** | -0.941*** |
| 2000 | 77,631 | 25.3% | 1.0 | -1.669*** | -0.946*** |
| 2001 | 78,621 | 25.3% | 1.0 | -1.678*** | -0.950*** |
| 2002 | 79,538 | 25.3% | 1.0 | -1.686*** | -0.954*** |
| 2003 | 80,467 | 25.3% | 1.0 | -1.692*** | -0.956*** |
| 2004 | 81,436 | 25.3% | 1.0 | -1.713*** | -0.962*** |
| 2005 | 82,392 | 25.4% | 1.0 | -1.715*** | -0.964*** |
| 2006 | 83,311 | 25.4% | 1.0 | -1.715*** | -0.966*** |
| 2007 | 84,219 | 25.5% | 1.0 | -1.713*** | -0.967*** |
| 2008 | 85,119 | 28.7% | 1.1 | -1.638*** | -0.934*** |
| 2009 | 86,025 | 28.7% | 1.1 | -1.634*** | -0.934*** |
| 2010 | 86,933 | 28.8% | 1.1 | -1.631*** | -0.935*** |
| 2011 | 87,840 | 28.9% | 1.1 | -1.629*** | -0.935*** |
| 2012 | 88,773 | 28.9% | 1.1 | -1.624*** | -0.936*** |
| 2013 | 89,709 | 29.0% | 1.1 | -1.621*** | -0.936*** |

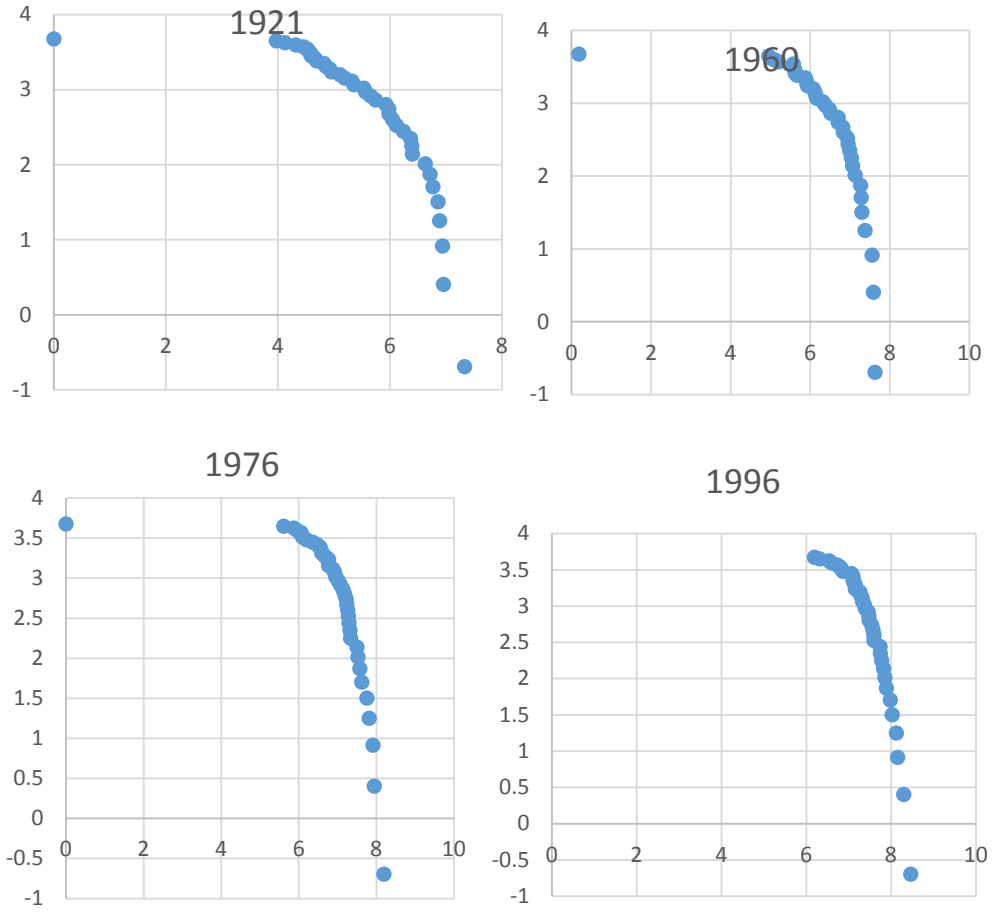



**Figure III.2: Zipf line of some years through 3 periods**

To measure the Zipf coefficient, the cities' population is ranked firstly, then the regression of the log rank minus 0.5 against log population density is hold as the Zipf slope. The table III.2 shows the fact that in early years (1921, 1931, 1936, 1943) the population varies greater than in division time or later years except the year 1977 1978 while Vietnam in the big change period. Some of the Zipf lines are described in the figure III.2 Hochiminh City remained the position of leading city from division to reunion because it was the new economic and political center of South Vietnam from division 1954 to 1975 and it is the natural economic center after the reunion 1975.

The figure III.3 show the change of historical population share of some main regions including Ha Noi, Hai Phong, Ha Nam Ninh, Nghe Tinh, Binh Tri Thien, Ho Chi Minh City, Dong Nai. The population share of year t is the ratio of population of each province divided to

the total population of that year. We can see the big change of the population share in the division period from 1954 to 1975 for the whole country. The population of Ho Chi Minh increased significantly from 1921 to 1975 then fell very quick after the reunification 1975 when US army withdrew from Sai Gon. Some years later, the population share of Ho Chi Minh City went up with high speed and become the largest city again confirm its role as an economic center of Vietnam. Ha Noi showed the different picture in compare to Ho Chi Minh City because this city has many times of changing the area due to political purpose such as its area is enlarged in several times (1959, 1961, 1978 and 2008), and narrow down in 1991. Therefore, there were big steps of population share change of Ha Noi in these times. While the population share of Hai Phong, a North city near Hanoi, remained the same and the population share of Dong Nai climbed up slightly, the population share of Binh Tri Thien which is the province that has heaviest bomb in the wartime and population share of Nghe Tinh where is the neighbor of Binh Tri Thien decreased after reunification 1975. The short-term causal effect of bomb amount and all of these changes is tested in the following time series and DID method.

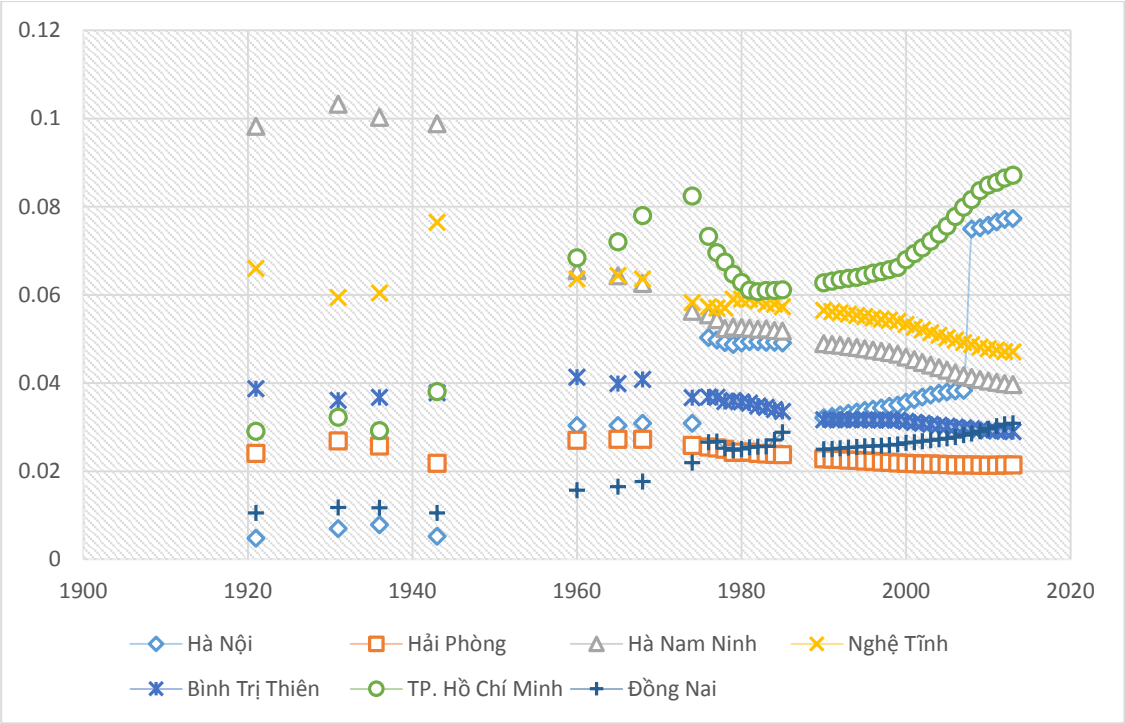



**Figure III.3: Historical population share of some main provinces**

### *4.2. Time series analysis*

To test whether the change of population share is significant in three periods union, division and reunification, and test whether there is causal effect of bomb and population change, the model of Redding et al. (2011) is introduced in this paper as followed:

$$\text{Popshare}_{it} = \sum_{i=1}^{40} \eta_{ip} + \sum_{i=1}^{40} \beta_{ip}\text{year}_t + u_{it} \quad (1)$$

In the model, $\text{Popshare}_{it}$ is the share of the population of each province *i* divided to the total population of Vietnam in year *t*, *p* indicates periods (union, division, and reunification). The set of province-period fixed effects is presented in the parameters $\eta_{ip}$ which allow for changes in mean population shares for each province between union, division and reunification periods. The coefficient $\boldsymbol{\beta_{ip}}$ indicates the trends in population shares for each province and they vary among three periods. $u_{it}$ is a stochastic error.

Beside the population share, other two variables which are log population and population growth also are examined with the similar model. The results of analysis are described in next paragraphs and table III.3 as well as in appendix 2 to appendix 4.

The figure III.3 shows that in the division time, the population shares of economic centers of North, South and Center such as Ha Noi, Quang Ninh, Quang Nam –Da Nang, and Ho Chi Minh City increases while Binh Tri Thien or Nghe Tinh province decreased significantly. These two provinces are near the border of North and South of Vietnam. In the reunion period, while other regions remain the same time trends, the share of the population of Ha Noi did not show the positive trend and Quang Nam – Da Nang (Center) and Quang Ninh (North) reduced their population share.

The estimated time trends of log population, population share and population growth of some provinces are shown in the table III.3. The time trends of North provinces, South provinces and provinces near the border are different. The North provinces and provinces near the Border Binh Tri Thien has more negative significant time trends for population share and population growth than the provinces in the South region. While log population value increases for all of provinces along the country in table III.3, the share of population of the provinces in the North area has negatively or not significantly change in the reunion period. It means that the reunion effect attenuates the population density. In the border region Binh Tri Thien, the population share declined significantly in both division and reunion periods and population growth has negative trend in the reunification period. The province which is economic center at the Middle region Quang Nam – Da Nang where belong to the South area presented the positive population share and population growth time trends in the division period but the share of population of this province reduce after 1975. The South provinces such as Ho Chi Minh City and Dong Nai province have positive tendency for population share and population growth at both periods and no negative time trend for their population growths. The more detail tables for whole 40 provinces are described in appendix 2 to appendix 4.

**Table III.3: Estimated time trends of some provinces for union, division and reunion periods**

| Regions | Provinces | Dependent variables | 1921-1953 | 1954-1975 | 1976-2013 |
|---|---|---|---|---|---|
| North | Ha Nam Ninh | ln Population | 0.0166*** | 0.0170*** | 0.00769*** |
| | | | (0.000786) | (0.000357) | (0.000674) |
| | | Population Share | 1.52e-05 | -0.000671*** | -0.000405*** |
| | | | (0.000110) | (0.000115) | (1.08e-05) |
| | | Population Growth | 0.0915*** | 0.171*** | -0.0601*** |
| | | | (0.0154) | (0.0555) | (0.0214) |
| | Ha Noi (Capital) | ln Population | 0.0237** | 0.0294*** | 0.0222*** |
| | | | (0.0111) | (0.00219) | (0.00463) |
| | | Population Share | 4.15e-05 | 4.02e-05*** | 0.000421 |
| | | | (7.90e-05) | (5.97e-06) | (0.000258) |
| | | Population Growth | -0.114 | -0.576* | 0.145 |
| | | | (0.207) | (0.328) | (0.329) |
| | Nghe Tinh | ln Population | 0.0220*** | 0.0215*** | 0.0102*** |
| | | | (0.00767) | (0.000332) | (0.000888) |
| | | Population Share | 0.000393 | -0.000401*** | -0.000324*** |
| | | | (0.000399) | (0.000153) | (2.40e-05) |
| | | Population Growth | 0.263*** | 0.0987** | -0.0841*** |
| | | | (0.0813) | (0.0413) | (0.0174) |
| Border | Binh Tri Thien | ln Population | 0.0153*** | 0.0201*** | 0.0101*** |
| | | | (0.00319) | (0.000755) | (0.000311) |
| | | Population Share | -4.40e-05 | -0.000311*** | -0.000203*** |
| | | | (5.68e-05) | (6.69e-05) | (8.61e-06) |
| | | Population Growth | 0.136*** | 0.00219 | -0.0433** |
| | | | (0.0173) | (0.0226) | (0.0211) |
| Middle | Quang Nam-Da Nang | ln Population | 0.0103 | 0.0358*** | 0.0138*** |
| | | | (0.00751) | (0.000802) | (0.000181) |
| | | Population Share | -0.000303 | 0.000285*** | -6.99e-05*** |
| | | | (0.000266) | (7.67e-05) | (8.95e-06) |
| | | Population Growth | 0.200*** | 0.251* | 0.0288 |
| | | | (0.0710) | (0.135) | (0.0403) |
| South | Ho Chi Minh City | ln Population | 0.0266*** | 0.0418*** | 0.0242*** |
| | | | (0.00531) | (0.00204) | (0.00113) |
| | | Population Share | 0.000340*** | 0.00104*** | 0.000572*** |
| | | | (0.000127) | (4.47e-05) | (0.000110) |
| | | Population Growth | 0.237** | -0.00759 | 0.109*** |
| | | | (0.105) | (0.0577) | (0.0245) |
| | Dong Nai | ln Population | 0.0170*** | 0.0522*** | 0.0202*** |
| | | | (0.00178) | (0.00616) | (0.000521) |
| | | Population Share | 5.45e-06 | 0.000450*** | 0.000105*** |
| | | | (3.84e-05) | (8.22e-05) | (2.18e-05) |
| | | Population Growth | 0.0429 | 0.269*** | -0.0655 |
| | | | (0.0421) | (0.0996) | (0.0704) |

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

### *4.3. Difference-in-Differences estimates*

To examine the statistical significance of the difference in time trends between Ha Noi and Ho Chi Minh city within the prewar and division periods, I next consider the difference-in-differences estimation (DID) for population share of these two provinces. To do this DID method, after estimation for the time trends of population share, the point estimates, standard errors, t or z statistics, p-values and confidence intervals for linear combinations of coefficients are computed by lincom stata command. The third column of panel A (Division) of table III.4 compares the time trends between the union and division periods for Ha Noi and Ho Chi Minh city (a difference within provinces across periods) and shows that Ho Chi Minh City's population share increased by 0.0007 percentage point per annum and is statistically significant, while Ha Noi's was not statistically significant change.

Considering the statistical significance of the difference in time trends between Hanoi and Ho Chi Minh city within the union and division periods (a difference within periods across provinces). The final row of panel A (Division) of table III.4 presents that within union of division periods, the difference in the population share of Ho Chi Minh is higher than Ha Noi and highly statistically significant. The bottom right-hand cell presents that the DID of population share was 0.0007 percent per annum and statistically significant, it means that the change of Hanoi population share is bigger than the change of Ho Chi Minh city.

Turning to the treatment effect of reunification comparing with division period, (3) column of the panel B of table III.4 shows that while population share of Hanoi increased from division to reunion periods, the population share of Ho Chi Minh city decreased significantly. The bottom row of B panel shows that within division time, the population share of Hanoi changes larger than the population share of Ho Chi Minh city. However, within the reunification periods, the population share of this two provinces did not show the difference. The last right-hand side bottom cell shows that the difference in differences of Hanoi is lower

than Ho Chi Minh city. Other estimation of DID for population growth and log population is described in the appendix 5 and appendix 6. All analysis of this part show there is short-term impact of division time (which is similar with bomb period) and the population of provinces in Vietnam. To answer the question about the long-run impact of bomb to the economic performance of provinces, I come to the V section.

**Table III.4: Estimated differences in time trends for population share**

| | (1) | (2) | (3) |
|---|---|---|---|
| | **A. Division** | | |
| | Period 1921-1953 | Period 1954-1975 | Between-Period Difference |
| Ha Noi | 4.15e-05 | 4.02e-05*** | 0.00000133 |
| | (7.90e-05) | (5.97e-06) | (0000793 ) |
| Ho Chi Minh City | 0.000340*** | 0.00104*** | -0.0006958*** |
| | (0.000127) | (4.47e-05) | ( .0001346) |
| Within-period difference | -.0002984*** | -.0009955*** | .0006972*** |
| | (.0001495) | (.0000451) | (.0001562) |
| | **B: Reunification** | | |
| | Period 1953-1975 | Period 1976-2013 | Between-Period Difference |
| Ha Noi | 4.02e-05*** | 0.000421 | -.0003805 * |
| | (5.97e-06) | (0.000258) | (.0002577) |
| Ho Chi Minh City | 0.00104*** | 0.000572*** | .0004637*** |
| | (4.47e-05) | (0.000110) | (.0001185) |
| Within-period difference | -.0009955*** | -.0001513 | -.0008442*** |
| | (.0000451) | (.00028) | (.0002836) |

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

**5. The long-run impact of bombing on economic performance of province**

Authors use the following framework to measure the long-run impact of bomb on the economic performance of each province:

$$y_{i2006} = \boldsymbol{\gamma_0} + \boldsymbol{\gamma_1 ln}\left(\frac{\boldsymbol{Bomb}_{i,1965-1975}}{\boldsymbol{Area}_i}\right) + \boldsymbol{\gamma_2 ln}\left(\frac{\boldsymbol{Pop}_{i,\,past}}{\boldsymbol{Area}_i}\right) + \boldsymbol{\gamma_3 lnArea}_i + \varepsilon_{it} \quad (2)$$

The dependent variable is output *y* of province *i* at the time year 2006. This output can be the number of firms or the number of labors of each province for all types of firm or State-owned enterprises (SOE) of private firm or Foreign Direct Investment Enterprise (FDI) or GDP of each province. While the dependent variable is the value of present time, the independent

variables are all in the past time. The first interest parameter is $\boldsymbol{\gamma_1}$ which show how large the density of US bombing $\frac{\boldsymbol{Bomb_{i,1965-1975}}}{\boldsymbol{Area_i}}$ at province i in the period of Vietnam War 1965-1975. $Bomb_i$ is total U.S. bombs, missiles, and rockets into province i and $Area_i$ is acreage of province i. The density of population is presented by $\frac{\boldsymbol{Pop_{i,past}}}{\boldsymbol{Area_i}}$ where the $Pop_i$ is the total population of province i at one year in the past such as 1921, 1943 or until 1978. As common sense, the expected sign of parameter $\boldsymbol{\gamma_1}$ is negative because the bomb should have negative on the economic performance of regions, while the opposite sign is expected for $\boldsymbol{\gamma_2}$ because the population in the past and population in recent years should change in the same direction. The area variable may have a positive impact on economic performance of each province.

From the first framework, the second equation is the result of the first one.

$$y_{i2006} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1 lnBomb_{i,1965-1975}} + \boldsymbol{\beta_2 lnPop_{i,past}} + \boldsymbol{\beta_3 lnArea_i} + \varepsilon_{it} \quad (3)$$

The formula (2) is the result of formula (1) in which $\boldsymbol{\beta_3 = \gamma_3 - \gamma_1 - \gamma_2}$, $\boldsymbol{\beta_1 = \gamma_1}$, $\boldsymbol{\beta_2 = \gamma_2}$ , and the expected signs of both $\boldsymbol{\gamma_2}$ and $\boldsymbol{\gamma_3}$ is positive then I can not predict the sign of $\boldsymbol{\beta_3}$ in the equation (2), it means that this $\boldsymbol{\beta_3}$ parameter may have positive or negative sign.

Table III.5 shows the basic result for the impact of bombing on the economic performance of provinces. The upper table is the result of bomb density and population density and the later table is result of the total bomb. Dependent variables are GDP, the number of all firms, the number of SOE, the number of private firm, and the number of FDI firm at province-level all in 2006. From the table, we can see the opposite expected result for bomb density, the higher the bomb density at a province, the higher the GDP of that province. This result also is highly and positively statistically significant for the concentration of firm in that province as well as the total number of labor at each province. When the type of firm is disaggregated into three types including SOE, private and FDI, results for the private firm and FDI firm are consistent with all firm. Not only bomb density has the positive sign but also

bomb has the positive sign with the output of provinces as presented in the latter table, and the private firm, as FDI firm are more sensitive with bombing than SOE firm.

Why bombing has the positive sign? Not only this paper shows this result but also the research of Miguel and Roland (2011) and other authors show the positive sign and not significant impact of bombing and economic performance in the long-term. There are multiple reasons for this result according to Miguel and Roland (2011). Firstly, almost bomb is in rural are where little infrastructures are destroyed. Second, Vietnamese government put the most effort in reconstruction after the war from 1976 to 1985 after the labor mobility policy from the 1970s to 1980s. Moreover, from 1960, 1970, school expansion and literacy campaigns were opened and the teachers and students were divided into small groups to avoid the bomb in the foxholes and had helmets that can protect them during U.S. attacked.

Turning to the Area variable, in the upper table, the result shows that in the most cases Area is not statistically significant and it has a positive relationship with only the number of SOE. The latter table shows the negative relationship of area with dependent variable as I have described that this relationship is unpredictable.

For the both cases, population density or total population in 1968 has a positive relationship with the number of firms. Authors also run separate regressions with other years from 1921 to 2013, and they also have consistent results with 1968 from division period to present years. The appendix 7 describes robust check with other indicators of historical economic output replacing for the historical population such as paddy productivity, the number of hospital and the number of hospital bed, the results for the total bomb, bombing density and area are still consistent with above results.

**Table III.5: Basic result for impact of bomb on the economic performance of provinces**

| | GDP | Number of all firm | Number of SOE | Number of private firm | Number of FDI firm |
|---|---|---|---|---|---|
| Bomb density | 0.225*** | 0.199*** | 0.0803 | 0.195*** | 2.059*** |
| | (0.0509) | (0.0550) | (0.0616) | (0.0540) | (0.570) |
| Population density 1968 | 0.144 | 0.480*** | 0.345** | 0.509*** | -0.487 |
| | (0.124) | (0.134) | (0.150) | (0.131) | (1.385) |
| Area | -0.250 | 0.218 | 0.376* | 0.240 | -0.702 |
| | (0.180) | (0.194) | (0.218) | (0.191) | (2.016) |
| Number of provinces | 40 | 40 | 40 | 40 | 40 |
| R square | 0.520 | 0.552 | 0.216 | 0.572 | 0.276 |

| | GDP | Number of all firm | Number of SOE | Number of private firm | Number of FDI firm |
|---|---|---|---|---|---|
| Total bomb | 0.237*** | 0.206*** | 0.0836 | 0.202*** | 2.087*** |
| | (0.0522) | (0.0568) | (0.0637) | (0.0557) | (0.594) |
| Population 1968 | 0.195 | 0.527*** | 0.364** | 0.555*** | 0.0229 |
| | (0.119) | (0.130) | (0.146) | (0.127) | (1.358) |
| Area | -0.571*** | -0.417*** | -0.0309 | -0.421*** | -1.769 |
| | (0.123) | (0.134) | (0.151) | (0.132) | (1.404) |
| Number of provinces | 40 | 40 | 40 | 40 | 40 |
| R square | 0.529 | 0.553 | 0.216 | 0.573 | 0.266 |

Note: All variables are in logarithms. The constants term are included in all cases. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

## 6. Conclusion

Unlike other researches that examine only short-term or long-term impact of war to the economic performance of a country, due to rich dataset of historical population and other historical economic proxy, this research has proved both long-term and contemporary impacts of the war and bomb with the concentration of firm (number of firms) as well as the wealth of a region (GDP at province level). To measure the contemporary impact, some simple indexes has been used in this paper such as Zipf slopes, the simple historical population graph, the relative variance of population density etc… as well as time trends estimation. In addition, the difference-in-differences methods also use to see the differences of the change of population density through periods. The proxy of war in this content is the classification of time into three periods uncluding union, division, and reunification. The results show that there is the short-term effect of division and reunification time on population density, population share or population growth of a city. These impacts are different among provinces in the North, South or close to the division border.

In addition to the calculation of the short-term impact of war on the population of provinces in Vietnam, this paper present the long-run impact of war by bombing proxy on the economic agglomeration or concentration of firm along provinces. With rich historical data from population to agriculture and health data beside the new dependent variables on the left-hand side like number of firms, a number of labors, even the results are not too robust but this research proves no significant or there are positive long-term impacts of the bomb on the economic performance of provinces.

Even the dataset is rich and there are contributions to the empirical study, this research remains some limitations. Firstly, the aggregation methodology does not provide one hundred percent of the accuracy because of the change in the name, the split and the merger of provinces in the long history by many times from 1921. However, authors already put the

most effort to make the aggregation. Secondly, the long-term impact can be calculated with more observations instead of only 40 provinces if authors only choose to present results with the population in the year 1968.

The further research should be done with more observations to measure the long-term impact of war on the economic performance. In addition, because of that the data for North and South separately is much more abundant than dataset for the whole country, another research for distinguishing regions can be taken into consideration. Moreover, the impact of the border 17 parallel should be one of the interesting candidate of a research topic.

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## Appendix 1: Aggregation methodology

| **code1921-1943** | **code1954-1975** | ***40Provinces (1976-1984)*** | **code1985** | **code1990-2003&bombdata** | **code2004-2007&DN2006** | **code2008-2013&GDP** |
|---|---|---|---|---|---|---|
| Ha Giang + Tuyen Quang | Ha Giang + Tuyen Quang | ***Ha Tuyen*** | Ha Giang + Tuyen Quang | Ha Giang + Tuyen Quang | Ha Giang + Tuyen Quang | Ha Giang + Tuyen Quang |
| Cao Bang | Cao Bang | ***Cao Bang*** | Cao Bang | Cao Bang | Cao Bang | Cao Bang |
| Lang Son | Lang Son | ***Lang Son*** | Lang Son | Lang Son | Lang Son | Lang Son |
| Lai Chau+ Dien Bien | Lai Chau | ***Lai Chau*** | Lai Chau | Lai Chau | Lai Chau+ Dien Bien | Lai Chau+ Dien Bien |
| Lao Cai + Yen Bai | Lao Cai + Yen Bai+Nghia Lo | ***Hoang Lien Son*** | Lao Cai + Yen Bai | Lao Cai + Yen Bai | Lao Cai + Yen Bai | Lao Cai + Yen Bai |
| Son La | Son La | ***Son La*** | Son La | Son La | Son La | Son La |
| Bac Can + Thai Nguyen | Bac Thai | ***Bac Thai*** | Bac Thai | Bac Can + Thai Nguyen | Bac Can + Thai Nguyen | Bac Can + Thai Nguyen |
| Quang Yen + Hai Ninh | Quang Ninh | ***Quang Ninh*** | Quang Ninh | Quang Ninh | Quang Ninh | Quang Ninh |
| Vinh Yen + Phuc Yen + Phu Tho | Vinh Phu | ***Vinh Phu*** | Vinh Phu | Vinh Phuc + Phu Tho | Vinh Phuc + Phu Tho | Vinh Phuc + Phu Tho |
| Bac Giang + Bac Ninh | Ha Bac | ***Ha Bac*** | Ha Bac | Bac Giang + Bac Ninh | Bac Giang + Bac Ninh | Bac Giang + Bac Ninh |
| Ha Noi | Ha Noi | ***Ha Noi*** | Ha Noi | Ha Noi | Ha Noi | Ha Noi+Ha Tay |
| Hai Phong+ Kien An | Hai Phong | ***Hai Phong*** | Hai Phong | Hai Phong | Hai Phong | Hai Phong |
| Ha Dong + Son Tay + Hoa Binh | Ha Tay + Hoa Binh | ***Ha Son Binh*** | Ha Son Binh | Ha Tay + Hoa Binh | Ha Tay + Hoa Binh | Hoa Binh |
| Hai Duong + Hung Yen | Hai Hung | ***Hai Hung*** | Hai Hung | Hai Duong + Hung Yen | Hai Duong + Hung Yen | Hai Duong + Hung Yen |
| Thai Binh | Thai Binh | ***Thai Binh*** | Thai Binh | Thai Binh | Thai Binh | Thai Binh |
| Ha Nam + Nam Dinh + Ninh Binh | Nam Ha + Ninh Binh | ***Ha Nam Ninh*** | Nam Ha + Ninh Binh | Ha Nam + Nam Dinh + Ninh Binh | Ha Nam + Nam Dinh + Ninh Binh | Ha Nam + Nam Dinh + Ninh Binh |
| Thanh Hoa | Thanh Hoa | ***Thanh Hoa*** | Thanh Hoa | Thanh Hoa | Thanh Hoa | Thanh Hoa |
| Nghe An + Ha | Nghe An + Ha | ***Nghe*** | Nghe An + | Nghe An + Ha | Nghe An + | Nghe An + |

| Tinh | Tinh | ***Tinh*** | Ha Tinh | Tinh | Ha Tinh | Ha Tinh |
|---|---|---|---|---|---|---|
| Quang Binh + Quang Tri + TT Hue | Quang Binh + Quang Tri + Thua Thien + Vinh Linh+Hue | ***Binh Tri Thien*** | Quang Binh + Quang Tri + Thua Thien Hue | Quang Binh + Quang Tri + Thua Thien Hue | Quang Binh + Quang Tri + TT Hue | Quang Binh + Quang Tri + TT Hue |
| Quang Nam + Da Nang | Quang Nam + Da Nang+Quang Tin | ***Quang Nam - Da Nang*** | Quang Nam - Da Nang | Quang Nam + Da Nang | Quang Nam + Da Nang | Quang Nam + Da Nang |
| Quang Ngai + Binh Dinh | Quang Ngai + Binh Dinh | ***Nghia Binh*** | Quang Ngai + Binh Dinh | Quang Ngai + Binh Dinh | Quang Ngai + Binh Dinh | Quang Ngai + Binh Dinh |
| Phu Yen + Khanh Hoa | Phu Yen + Khanh Hoa+Cam Ranh | ***Phu Khanh*** | Phu Yen + Khanh Hoa | Phu Yen + Khanh Hoa | Phu Yen + Khanh Hoa | Phu Yen + Khanh Hoa |
| Binh Thuan + Ninh Thuan | Binh Thuan + Ninh Thuan+Binh Tuy | ***Thuan Hai*** | Binh Thuan + Ninh Thuan | Binh Thuan + Ninh Thuan | Binh Thuan + Ninh Thuan | Binh Thuan + Ninh Thuan |
| Kon Tum | Kon Tum+ Pleiku+ Phu Bon | ***Gia Lai - Kon Tum*** | Kon Tum + Gia Lai | Kon Tum + Gia Lai | Gia Lai + Kon Tum | Gia Lai + Kon Tum |
| Dak Lak | Dak Lak+Quang Duc | ***Dak Lak*** | Dak Lak+Quang Duc | Dak Lak | Dak Lak+Dak Nong | Dak Lak+Dak Nong |
| Lang Biang/Đà Lạt | Lam Dong + Tuyen Duc + Đà Lạt | ***Lam Dong*** | Lam Dong | Lam Dong | Lam Dong | Lam Dong |
| Sai Gon + Gia Dinh + TP Cho Lon | Sai Gon + Gia Dinh | ***TP. Ho Chi Minh*** | TP Ho Chi Minh | TP Ho Chi Minh | Ho Chi Minh | Ho Chi Minh |
| Thu Dau Mot | Phuoc Thanh + Binh Duong + Binh Long + Phuoc Long | ***Song Be*** | Song Be | Binh Duong + Binh Phuoc | Binh Duong + Binh Phuoc | Binh Duong + Binh Phuoc |
| Tay Ninh | Tay Ninh | ***Tay Ninh*** | Tay Ninh | Tay Ninh | Tay Ninh | Tay Ninh |
| Dong Nai + Bien Hoa | Dong Nai + Bien Hoa+Phuoc Tuy+Long Khanh | ***Dong Nai*** | Dong Nai | Dong Nai | Dong Nai | Dong Nai |
| Ba Ria + Con Dao +Cap St. Jacques/Vũng Tàu | Vung Tau + Con Son | ***Vung Tau - Con Dao*** | Vung Tau - Con Dao | Ba Ria - Vung Tau | Ba Ria Vung Tau | Ba Ria Vung Tau |
| Cho Lon + Tan An | Kien Tuong + Long An+Hau Nghia | ***Long An*** | Long An | Long An | Long An | Long An |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sa Dec | Kien Phong+ Sa Dec | ***Dong Thap*** | Dong Thap | Dong Thap | Dong Thap | Dong Thap |
| Chau Doc + Long Xuyen | An Giang + Chau Doc | ***An Giang*** | An Giang | An Giang | An Giang | An Giang |
| Go Cong + My Tho | Dinh Tuong + Go Cong | ***Tien Giang*** | Tien Giang | Tien Giang | Tien Giang | Tien Giang |
| Ben Tre | Kien Hoa | ***Ben Tre*** | Ben Tre | Ben Tre | Ben Tre | Ben Tre |
| Vinh Long + Tra Vinh | Vinh Long + Vinh Binh | ***Cuu Long*** | Vinh Long + Tra Vinh | Vinh Long + Tra Vinh | Vinh Long + Tra Vinh | Vinh Long + Tra Vinh |
| Can Tho + Soc Trang | Ba Xuyen + Chuong Thien + Phong Dinh | ***Hau Giang*** | Can Tho + Soc Trang | Can Tho + Soc Trang | Hau Giang+Can Tho + Soc Trang | Hau Giang+Can Tho + Soc Trang |
| Kien Giang | Kien Giang | ***Kien Giang*** | Kien Giang | Kien Giang | Kien Giang | Kien Giang |
| Bac Lieu | An Xuyen+Bac Lieu | ***Minh Hai*** | Minh Hai | Ca Mau + Bac Lieu | Ca Mau + Bac Lieu | Ca Mau + Bac Lieu |

## Appendix 2: Estimated time trends for log population for three periods

| | (1) | (2) | (3) | | (1) | (2) | (3) |
|---|---|---|---|---|---|---|---|
| PROVINCES | lnPopulation | lnPopulation | lnPopulation | PROVINCES | lnPopulation | lnPopulation | lnPopulation |
| | 1921-1953 | 1954-1975 | 1976-2013 | | 1921-1953 | 1954-1975 | 1976-2013 |
| An Giang | 0.0154*** | 0.0387*** | 0.0106*** | Lam Dong | 0.0779*** | 0.0539*** | 0.0365*** |
| | (0.000387) | (0.00507) | (0.000843) | | (0.0286) | (0.00115) | (0.00150) |
| Bac Thai | 0.0329*** | 0.0452*** | 0.0182*** | Lang Son | 0.0340*** | 0.0320*** | 0.0140*** |
| | (0.00381) | (0.00366) | (0.000928) | | (0.00305) | (0.00348) | (0.000899) |
| Ben Tre | 0.0126*** | 0.0187** | 0.00626*** | Long An | 0.0148*** | 0.0217*** | 0.0134*** |
| | (0.00149) | (0.00789) | (0.000944) | | (0.00149) | (0.00377) | (0.000680) |
| Binh Tri Thien | 0.0153*** | 0.0201*** | 0.0101*** | Minh Hai | 0.0250*** | 0.0655*** | 0.0183*** |
| | (0.00319) | (0.000755) | (0.000311) | | (0.00162) | (0.00917) | (0.00113) |
| Cao Bang | 0.0270*** | 0.0248*** | 0.00155* | Nghe Tinh | 0.0220*** | 0.0215*** | 0.0102*** |
| | (0.00201) | (0.000410) | (0.000801) | | (0.00767) | (0.000332) | (0.000888) |
| Cuu Long | 0.0105*** | 0.000810 | 0.0100*** | Nghia Binh | 0.0144** | 0.0233*** | 0.00900*** |
| | (0.00116) | (0.00710) | (0.000886) | | (0.00642) | (0.00761) | (0.000853) |
| Dak Lak | -0.00531 | 0.0461*** | 0.0519*** | Phu Khanh | 0.0182*** | 0.0383*** | 0.0170*** |
| | (0.00368) | (0.00459) | (0.00231) | | (0.00131) | (0.00509) | (0.000663) |
| Dong Nai | 0.0170*** | 0.0522*** | 0.0202*** | Quang Nam - Da Nang | 0.0103 | 0.0358*** | 0.0138*** |
| | (0.00178) | (0.00616) | (0.000521) | | (0.00751) | (0.000802) | (0.000181) |
| Dong Thap | 0.0108*** | 0.0877*** | 0.0118*** | Quang Ninh | 0.0358*** | 0.0416*** | 0.0138*** |
| | (0.00148) | (0.00787) | (0.000858) | | (0.00136) | (0.00236) | (0.000222) |
| Gia Lai - Kon Tum | 0.0221** | 0.0309*** | 0.0356*** | Son La | 0.0145*** | 0.0408*** | 0.0271*** |
| | (0.0111) | (0.00216) | (0.000976) | | (0.00130) | (0.000694) | (0.000807) |
| Ha Bac | 0.0166*** | 0.0292*** | 0.0147*** | Song Be | 0.00713 | -0.0103 | 0.0424*** |
| | (0.000179) | (0.00169) | (0.000778) | | (0.00775) | (0.00955) | (0.00105) |
| Ha Nam Ninh | 0.0166*** | 0.0170*** | 0.00769*** | TP. Ho Chi Minh | 0.0266*** | 0.0418*** | 0.0242*** |
| | (0.000786) | (0.000357) | (0.000674) | | (0.00531) | (0.00204) | (0.00113) |
| Ha Noi | 0.0237** | 0.0294*** | 0.0222*** | Tay Ninh | 0.0383*** | 0.0354*** | 0.0139*** |
| | (0.0111) | (0.00219) | (0.00463) | | (0.00846) | (0.0135) | (0.000709) |
| Ha Son Binh | 0.00908*** | 0.0230*** | -0.00301 | Thai Binh | 0.0123*** | 0.0114*** | 0.00508*** |
| | (0.000913) | (0.000792) | (0.00977) | | (0.000692) | (0.00126) | (0.000537) |
| Ha Tuyen | 0.0261*** | 0.0443*** | 0.0208*** | Thanh Hoa | 0.0164*** | 0.0207*** | 0.0105*** |
| | (0.00604) | (0.00369) | (0.000761) | | (0.00372) | (0.000929) | (0.000962) |
| Hai Hung | 0.0155*** | 0.0182*** | 0.00913*** | Thuan Hai | 0.0221*** | 0.0399*** | 0.0207*** |
| | (0.000517) | (0.000647) | (0.000647) | | (0.00197) | (0.00937) | (0.000803) |
| Hai Phong | 0.0127*** | 0.0249*** | 0.0116*** | Tien Giang | 0.0116*** | 0.0263*** | 0.00930*** |
| | (0.00313) | (0.000810) | (0.000211) | | (0.000276) | (0.00694) | (0.000629) |
| Hau Giang | 0.0121*** | 0.0192 | 0.0130*** | Vinh Phu | 0.0168*** | 0.0261*** | 0.0158*** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (0.00243) | (0.0147) | (0.000914) | | (0.00166) | (0.00347) | (0.00141) |
| Hoang Lien Son | 0.0284*** | 0.0468*** | 0.0190*** | Vung Tau - Con Dao | 0.0118*** | 0.312*** | 0.0810*** |
| | (0.000104) | (0.00429) | (0.000973) | | (0.000425) | (0.0956) | (0.00730) |
| Kien Giang | 0.0221*** | 0.0149 | 0.0183*** | Constant | 6.705*** | 6.705*** | 6.705*** |
| | (0.00357) | (0.0158) | (0.000821) | | (0.00707) | (0.00707) | (0.00707) |
| Lai Chau | 0.0109*** | 0.0405*** | 0.0331*** | Observations | 1,678 | 1,678 | 1,678 |
| | (0.00285) | (0.00192) | (0.000493) | R-squared | 0.980 | 0.980 | 0.980 |

# Appendix 3: Estimated time trends for population share for three periods

| PROVINCES | Population Share | Population Share | Population Share | PROVINCES | Population Share | Population Share | Population Share |
|---|---|---|---|---|---|---|---|
| | 1921-1953 | 1954-1975 | 1976-2013 | | 1921-1953 | 1954-1975 | 1976-2013 |
| An Giang | -2.74e-05 | 0.000314*** | -0.000156*** | Lam Dong | 8.64e-06 | 0.000172*** | 0.000213*** |
| | (4.63e-05) | (8.40e-05) | (1.24e-05) | | (5.76e-06) | (1.02e-05) | (9.98e-06) |
| Bac Thai | 0.000135*** | 0.000246*** | 2.95e-05*** | Lang Son | 0.000135*** | 3.55e-05 | -2.10e-05*** |
| | (2.20e-05) | (8.18e-05) | (9.44e-06) | | (1.54e-05) | (5.43e-05) | (4.53e-06) |
| Ben Tre | -6.21e-05*** | -0.000160* | -0.000172*** | Long An | -3.30e-05*** | -0.000113*** | -5.06e-05*** |
| | (2.94e-06) | (9.32e-05) | (7.85e-06) | | (9.61e-06) | (3.83e-05) | (5.43e-06) |
| Binh Tri Thien | -4.40e-05 | -0.000311*** | -0.000203*** | Minh Hai | 0.000108*** | 0.000464*** | 4.57e-05*** |
| | (5.68e-05) | (6.69e-05) | (8.61e-06) | | (7.90e-06) | (0.000124) | (1.63e-05) |
| Cao Bang | 9.42e-05*** | -2.92e-05 | -0.000109*** | Nghe Tinh | 0.000393 | -0.000401*** | -0.000324*** |
| | (8.71e-06) | (2.34e-05) | (6.45e-06) | | (0.000399) | (0.000153) | (2.40e-05) |
| Cuu Long | -0.000142*** | -0.000824*** | -0.000164*** | Nghia Binh | -0.000124 | -0.000228 | -0.000259*** |
| | (1.31e-05) | (0.000155) | (1.22e-05) | | (0.000264) | (0.000244) | (1.77e-05) |
| Dak Lak | -0.000105*** | 0.000117*** | 0.000580*** | Phu Khanh | 3.13e-05 | 0.000226*** | 1.47e-05 |
| | (2.03e-05) | (3.29e-05) | (2.25e-05) | | (5.36e-05) | (6.34e-05) | (1.01e-05) |
| Dong Nai | 5.45e-06 | 0.000450*** | 0.000105*** | Quang Nam - Da Nang | -0.000303 | 0.000285*** | -6.99e-05*** |
| | (3.84e-05) | (8.22e-05) | (2.18e-05) | | (0.000266) | (7.67e-05) | (8.95e-06) |
| Dong Thap | -6.95e-05*** | 0.000779*** | -9.33e-05*** | Quang Ninh | 0.000211*** | 0.000184*** | -3.47e-05*** |
| | (3.26e-06) | (9.27e-05) | (1.04e-05) | | (1.48e-05) | (6.06e-05) | (6.82e-06) |
| Gia Lai - Kon Tum | 0.000104 | 2.64e-05 | 0.000291*** | Son La | -1.07e-05*** | 8.53e-05*** | 0.000116*** |
| | (0.000221) | (3.94e-05) | (6.12e-06) | | (2.09e-06) | (1.01e-05) | (3.10e-06) |
| Ha Bac | 3.68e-06 | 3.49e-05 | -5.20e-05*** | Song Be | -6.91e-05 | -0.000449*** | 0.000493*** |
| | (6.98e-05) | (0.000124) | (1.07e-05) | | (7.71e-05) | (0.000104) | (3.70e-05) |
| Ha Nam Ninh | 1.52e-05 | -0.000671*** | -0.000405*** | TP. Ho Chi Minh | 0.000340*** | 0.00104*** | 0.000572*** |
| | (0.000110) | (0.000115) | (1.08e-05) | | (0.000127) | (4.47e-05) | (0.000110) |
| Ha Noi | 4.15e-05 | 4.02e-05*** | 0.000421 | Tay Ninh | 0.000171*** | 7.34e-05 | -3.23e-05*** |
| | (7.90e-05) | (5.97e-06) | (0.000258) | | (5.88e-05) | (0.000102) | (9.22e-06) |
| Ha Son Binh | -0.000453*** | -0.000230*** | -0.000242 | Thai Binh | -0.000224*** | -0.000580*** | -0.000278*** |
| | (0.000149) | (7.12e-05) | (0.000216) | | (5.20e-05) | (4.38e-05) | (7.42e-06) |
| Ha Tuyen | 7.33e-05** | 0.000216*** | 7.13e-05*** | Thanh Hoa | -2.89e-06 | -0.000376** | -0.000257*** |
| | (3.27e-05) | (7.98e-05) | (5.06e-06) | | (9.93e-05) | (0.000161) | (2.16e-05) |
| Hai Hung | -6.24e-05 | -0.000442*** | -0.000265*** | Thuan Hai | 5.44e-05*** | 0.000187* | 8.22e-05*** |
| | (0.000134) | (7.16e-05) | (1.15e-05) | | (1.28e-05) | (0.000107) | (7.22e-06) |
| Hai Phong | -8.67e-05 | -8.40e-05** | -0.000108*** | Tien Giang | -0.000126*** | -3.79e-05 | -0.000152*** |
| | (0.000117) | (3.91e-05) | (7.26e-06) | | (4.15e-05) | (9.97e-05) | (4.17e-06) |
| Hau Giang | -0.000137*** | -0.000303 | -0.000135*** | Vinh Phu | 1.27e-05*** | -7.13e-05 | -1.42e-05 |
| | (2.54e-05) | (0.000393) | (2.19e-05) | | (4.90e-06) | (0.000199) | (2.85e-05) |
| Hoang Lien Son | 8.31e-05*** | 0.000262*** | 4.11e-05*** | Vung Tau - Con Dao | -1.76e-05*** | 0.000190*** | 0.000355*** |
| | (1.04e-05) | (8.93e-05) | (9.02e-06) | | (5.19e-06) | (2.67e-05) | (2.47e-05) |
| Kien Giang | 9.63e-05 | -0.000178 | 3.63e-05*** | Constant | 0.0250*** | 0.0250*** | 0.0250*** |
| | (9.65e-05) | (0.000168) | (8.07e-06) | | (0.000138) | (0.000138) | (0.000138) |
| Lai Chau | -1.77e-05 | 6.45e-05*** | 0.000131*** | Observations | 1,680 | 1,680 | 1,680 |
| | (1.50e-05) | (2.15e-05) | (5.06e-06) | R-squared | 0.964 | 0.964 | 0.964 |

## Appendix 4: Estimated time trends for population growth for three periods

| | (1) | (2) | (3) | | (1) | (2) | (3) |
|---|---|---|---|---|---|---|---|
| | 1921-1953 | 1954-1975 | 1976-2013 | | 1921-1953 | 1954-1975 | 1976-2013 |
| Provinces | Growth | Growth | Growth | PROVINCES | Growth | Growth | Growth |
| An Giang | 0.0686* | 0.263*** | -0.0763*** | Lam Dong | -0.218 | -1.122** | -0.0866*** |
| | (0.0376) | (0.101) | (0.0142) | | (0.498) | (0.552) | (0.0326) |
| Bac Thai | 0.234*** | -0.00198 | -0.0603* | Lang Son | 0.223*** | 0.0323 | -0.0757* |
| | (0.0241) | (0.0985) | (0.0314) | | (0.0109) | (0.117) | (0.0400) |
| Ben Tre | 0.0887*** | 0.179 | -0.145** | Long An | 0.0988*** | 0.162 | -0.0880*** |
| | (0.00423) | (0.240) | (0.0604) | | (0.0229) | (0.184) | (0.0212) |
| Binh Tri Thien | 0.136*** | 0.00219 | -0.0433** | Minh Hai | 0.148*** | 0.268 | -0.177*** |
| | (0.0173) | (0.0226) | (0.0211) | | (0.0266) | (0.312) | (0.0641) |
| Cao Bang | 0.165*** | 0.0913** | -0.0909** | Nghe Tinh | 0.263*** | 0.0987** | -0.0841*** |
| | (0.0403) | (0.0397) | (0.0400) | | (0.0813) | (0.0413) | (0.0174) |
| Cuu Long | 0.0722*** | -0.0894 | -0.109*** | Nghia Binh | 0.198*** | 0.327*** | -0.0624* |
| | (0.0157) | (0.411) | (0.0328) | | (0.0564) | (0.0815) | (0.0320) |
| Dak Lak | -0.0677 | 0.0107 | -0.194* | Phu Khanh | 0.0675** | 0.266*** | -0.0598 |
| | (0.158) | (0.316) | (0.108) | | (0.0309) | (0.0668) | (0.0532) |
| Dong Nai | 0.0429 | 0.269*** | -0.0655 | Quang Nam - Da Nang | 0.200*** | 0.251* | 0.0288 |
| | (0.0421) | (0.0996) | (0.0704) | | (0.0710) | (0.135) | (0.0403) |
| Dong Thap | 0.0797*** | 0.680 | -0.132*** | Quang Ninh | 0.181** | 0.133 | -0.0253 |
| | (0.00271) | (0.662) | (0.0389) | | (0.0839) | (0.111) | (0.0240) |
| Gia Lai - Kon Tum | -0.114 | 0.214 | -0.130** | Son La | 0.0936*** | 0.126*** | -0.119** |
| | (0.296) | (0.237) | (0.0569) | | (0.00301) | (0.0267) | (0.0467) |
| Ha Bac | 0.0747*** | 0.123 | -0.0733*** | Song Be | -0.120 | -0.257 | -0.0479 |
| | (0.0214) | (0.0831) | (0.0139) | | (0.0949) | (0.406) | (0.108) |
| Ha Nam Ninh | 0.0915*** | 0.171*** | -0.0601*** | TP. Ho Chi Minh | 0.237** | -0.00759 | 0.109*** |
| | (0.0154) | (0.0555) | (0.0214) | | (0.105) | (0.0577) | (0.0245) |
| Ha Noi | -0.114 | -0.576* | 0.145 | Tay Ninh | 0.364*** | 0.556** | -0.126 |
| | (0.207) | (0.328) | (0.329) | | (0.138) | (0.243) | (0.113) |
| Ha Son Binh | 0.0253 | 0.128*** | -0.199 | Thai Binh | 0.0704*** | 0.0995* | -0.0501* |
| | (0.0445) | (0.0232) | (0.257) | | (0.0108) | (0.0517) | (0.0294) |
| Ha Tuyen | 0.239*** | -0.0514 | -0.0652*** | Thanh Hoa | 0.153** | -0.0225 | -0.0826*** |
| | (0.0418) | (0.135) | (0.00924) | | (0.0718) | (0.0172) | (0.0140) |
| Hai Hung | 0.0640*** | 0.121*** | -0.0612** | Thuan Hai | 0.131** | 0.296 | -0.0830*** |
| | (0.0206) | (0.0244) | (0.0251) | | (0.0628) | (0.219) | (0.0204) |
| Hai Phong | -0.00316 | -0.00534 | -0.0266 | Tien Giang | 0.0553*** | 0.299*** | -0.0857** |
| | (0.0485) | (0.0381) | (0.0180) | | (0.0116) | (0.105) | (0.0380) |
| Hau Giang | 0.106*** | 0.374 | -0.137*** | Vinh Phu | 0.112*** | 0.0263 | -0.0554 |
| | (0.0389) | (0.413) | (0.0531) | | (0.0111) | (0.0980) | (0.0408) |
| Hoang Lien Son | 0.133*** | -0.0912 | -0.0563* | Vung Tau - Con Dao | 0.0600** | 0.306 | 0.472 |
| | (0.0382) | (0.0932) | (0.0313) | | (0.0233) | (4.072) | (0.567) |
| Kien Giang | 0.0338 | 0.523* | -0.183* | Constant | 2.785*** | 2.785*** | 2.785*** |
| | (0.0587) | (0.294) | (0.0972) | | (0.408) | (0.408) | (0.408) |
| Lai Chau | -0.00636 | -0.0814** | -0.0474* | Observations | 1,678 | 1,678 | 1,678 |
| | (0.0461) | (0.0365) | (0.0273) | R-squared | 0.168 | 0.168 | 0.168 |

## Appendix 5: Estimated differences in time trends for population growth

| | (1) | (2) | (3) |
|---|---|---|---|
| | **A. Division** | | |
| | Period | Period | |
| | 1921-1953 | 1954-1975 | Between-Period Difference |
| Ha Noi | -0.114 | -0.576* | .4617643 |
| | (0.207) | (0.328) | (.3872405) |
| Ho Chi Minh City | 0.237** | -0.00759 | .2441174** |
| | (0.105) | (0.0577) | (.1195674 ) |
| Within-period difference | -.3504974 | -.5681443* | 0.2176469 |
| | ( .2315652) | (.3326095) | (.4052796) |
| | **B: Reunification** | | |
| | Period | Period | |
| | 1953-1975 | 1976-2013 | Between-Period Difference |
| Ha Noi | -0.576* | 0.145 | -.720565 |
| | (0.328) | (0.329) | (.4639531) |
| Ho Chi Minh City | -0.00759 | 0.109*** | -.1165691* |
| | (0.0577) | (0.0245) | (.062675) |
| Within-period difference | -.5681443* | .0358516 | -.6039959 |
| | (.3326095) | (.3294715) | (.4681673) |

## Appendix 6: Estimated differences in time trends for log population

| | (1) | (2) | (3) |
|---|---|---|---|
| | **A. Division** | | |
| | Period | Period | |
| | 1921-1953 | 1954-1975 | Between-Period Difference |
| Ha Noi | 0.0237** | 0.0294*** | -.0056612 |
| | (0.0111) | (0.00219) | (.0112701) |
| Ho Chi Minh City | 0.0266*** | 0.0418*** | -.0151739*** |
| | (0.00531) | (0.00204) | (.0056901) |
| Within-period difference | -.0029281 | -.0124409*** | .0095127 |
| | (.0122662) | (.0029887) | (.012625) |
| | **B: Reunification** | | |
| | Period | Period | |
| | 1953-1975 | 1976-2013 | Between-Period Difference |
| Ha Noi | 0.0294*** | 0.0222*** | .0071325 |
| | (0.00219) | (0.00463) | (.0051177) |
| Ho Chi Minh City | 0.0418*** | 0.0242*** | .0175841*** |
| | (0.00204) | (0.00113) | (.002327) |
| Within-period difference | -.0124409*** | -.0019893 | -.0104516* |
| | (.0029887) | (.0047617) | (.005622) |

## Appendix 7: Impact of some other economic indicators in the past on the present economic performance

| | GDP | GDP | GDP | Number of all firms | Number of all firms | Number of all firms |
|---|---|---|---|---|---|---|
| Bomb Density | 0.243*** | 0.244*** | 0.210*** | 0.263*** | 0.262*** | 0.194*** |
| | (0.0479) | (0.0488) | (0.0469) | (0.0597) | (0.0604) | (0.0488) |
| Area | -0.387*** | -0.408*** | -0.356*** | -0.345** | -0.316** | -0.211* |
| | (0.115) | (0.116) | (0.109) | (0.144) | (0.144) | (0.114) |
| Paddy productivity | -0.0283 | | | 0.0294 | | |
| | (0.0200) | | | (0.0250) | | |
| Number of hospital | | 0.0162 | | | 0.0193 | |
| | | (0.0225) | | | (0.0279) | |
| Number of hospital bed | | | 0.334** | | | 0.657*** |
| | | | (0.127) | | | (0.132) |
| Number of provinces | 40 | 40 | 40 | 40 | 40 | 40 |
| R square | 0.528 | 0.509 | 0.582 | 0.414 | 0.399 | 0.639 |

| | GDP | GDP | GDP | Number of all firms | Number of all firms | Number of all firms |
|---|---|---|---|---|---|---|
| Bomb | 0.253*** | 0.255*** | 0.225*** | 0.258*** | 0.258*** | 0.200*** |
| | (0.0517) | (0.0524) | (0.0482) | (0.0664) | (0.0664) | (0.0511) |
| Area | -0.586*** | -0.605*** | -0.524*** | -0.515*** | -0.515*** | -0.359*** |
| | (0.125) | (0.125) | (0.116) | (0.159) | (0.159) | (0.123) |
| Paddy productivity | -0.0251 | | | 0.0182 | | |
| | (0.0204) | | | (0.0289) | | |
| Number of hospital | | 0.0151 | | | 0.0182 | |
| | | (0.0228) | | | (0.0289) | |
| Number of hospital bed | | | 0.371*** | | | 0.695*** |
| | | | (0.123) | | | (0.131) |
| Number of provinces | 40 | 40 | 40 | 40 | 40 | 40 |
| R square | 0.514 | 0.500 | 0.596 | 0.355 | 0.355 | 0.635 |