Vietnamese Inter – regional labor migration: system approach to the modeling for1989, 1999, and 2009

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I. Introduction

Migration and natural increase in regional population influence the long-term development potential of a nation. It is also true that the population in certain regions increases due to industrialization and modernization in order to survive in the market economy. In contrast, some other regions become relatively unattractive for labor to immigrate to, and these become isolated as compared to neighboring regions.

In the scenario of economic growth of developing countries, through in-migration and out-migration of labor, the distribution of population and wealth changes dramatically. This is one of the reasons why policymakers, researchers, experts of official development assistance, and donors are concerned about migration with a long-term vision for the sustainable economic development of developing countries.

With the dynamic change in the structure of the labor force, migration is one of the most difficult phenomena for researchers to estimate with a focus on the perspectives of the entire country's development. Because, even though classically economists adopted the view as expressed in Hicks (1932), that "difference in net economic advantage, chiefly differences in wages, is the main cause of migration," there are also non-economic advantages that influence both in-migration and out-migration of labor. According to modern economists, non-economic valuables and quality of life indicators exert a statistically significant influence on migration. In other words, opportunity costs such as cost of living differences, employment prospects, and public amenities such as comfortable climate or sightseeing advantages have to be considered in the migration function to measure the exact impact of economic factors—for example, to analyze how much high wage expectation of the urban region impacts the inflow of workers into the region and how much overpopulation of the rural region causes outflow of labor into other regions. For this purpose, Poot (1986) used an aggregate data analysis of system approach and estimated the migration function for New Zealand for the period 1971–76 with both social and economic factors included in the model.

The advantage of the Poot model is that by using aggregate data, he succeeded in clearly measuring the difference between economic and non-economic factors. This aggregate data used a migration model and is built with a simultaneous equation system of demand and supply sides. I

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estimate three migration equations for Vietnam for the period 1984–89, 1994–99, and 2004–09, respectively. However, to provide useful implication for political research, I believed that the long-term model is worthy of considering for data analysis. In his study, the error correction model was also used to estimate long-term migration in Vietnam, and it is shown that Vietnamese migration would converge with a convergence speed of 0.53 to the estimated model, and 90% by 2020 and 99% by 2050. This implies that the Poot model is adaptable to inter-temporal analysis and provides robustness for the estimation and is also useful for political analysis.

The model is applied to the data of Vietnam labor force age migration in provinces for the periods 1984–89, 1994–99, and 2004–09 from the Vietnam population census. Section II discusses the data and the estimation technique. Section III presents the results. Section IV estimates and discusses long-term migration from the error correction model (ECM) on the basis of the results of estimation, and Section V presents the concluding remarks.

II. The Data and model setting

Data

With regard to migration data, I use the national survey data of Vietnam population census for 1989, 1999, and 2009. The database was created from data collected from interviews over five years with the cooperation of the Vietnamese statistic office and the United Nations Population Fund (UNFPA). In this paper, I used the aggregate data in each province in Vietnam. For example, in the 1989 census, 1,451,879 people were interviewed, and this included those who moved to other provinces in the period 1984 to 1989. In this paper, labor is defined as those aged from 15 to under 65 years. In 1984, Vietnam comprised three cities—Hanoi, Hai Phong, and Ho Chi Minh—and 37 provinces. Therefore, for aggregate data analysis of interprovince labor migration, I used a city/province matrix for 40 cities and 3,540 (40 × 39) units of observation data. In Vietnam, the administrative region has changed; for example, Da Nang city used to belong to Quang Nam and Da Nang province, but became an independent city in 1997. Moreover, Hanoi city was merged with Ha Tay province and its other neighboring districts in 2008. For the purpose of comparing the estimated results for 1999 to the estimated results of 2009, I created a unified dataset of a 60-province matrix for 1999 and 2009 on the basis of the number of provinces in the 1999 census[1]. With regard to the socioeconomic data of provinces—such as total population, farmers' population, and average annual income of provinces—I used annual data from *The Statistic Yearbook*, which is published by the Vietnamese statistical office.

[1] Regard with name list and the number of provinces in 1989, 1999, and 2009 data set, see in Appendix.

Model setting

Observing that migration flows over a certain period, Ravenstein (1885) explained migration in a similar manner as Newton's law of gravity: "We have already proved that the great body of our migrants only proceed a short distance, and that there takes place consequently a universal shifting or displacement of the population, which produces "currents of migration setting in the direction of the great centers of commerce and industry which absorb the migrants.[2]"

This is taken into account mathematically in the following manner[3]:

$$(1) \qquad M_{ij} = P_i^{\alpha} P_j^{\beta} D_{ij}^{\delta}, \qquad i, j = 1, \ldots, n \qquad i \neq j$$

where M_{ij} is the number of migrants from i area to j area, P_i (P_j) is the population of i(j) area, and D_{ij} is the distance between i and j. The parameters α and β are expected to be positive (>0). Because the larger the population in region (i) or (j), the greater the number of people who move out from or in to the region, similar to the effect of gravity. Further, in accordance with the rule of gravity, the greater the distance between regions (i) and (j), the lower the influence of gravity between the two regions. This leads to the expectation that parameter δ is negative (<0).

It would be surprising if such a simple model would provide a good explanation of migration in an entire country. Indeed, the pure gravity model could be rejected on a number of grounds. First, it is not based on a behavioral theory. Second, it is unrealistic to assume that the flow between region (i) and (j) is not affected by characteristics of the other areas. Third, the model explains migration as the flow of people away from the population in the current area. Fourth, simultaneous equation bias may exist if P_i and P_j are rather sensitive to changes in the movement from regions (i) to (j), M_{ij}, and from regions (j) to (i), M_{ji}. Subsequently, I use the right-hand side (RHS) of equation (1) as the generalized costs of the movement, and use index F_{ij} to express the "cost function" portion of the migration function.

A general class of models, which includes the single equation gravity models as a special case, can be derived from the general theory of movements presented in Alonso (1978). The appeal of this theory lies in its generality: the theory can also be applied to, for example, international trade, shopping trips, and market shares of goods of a product in different regions. While there have been some applications of the Alonso theory to international population flows, notably with respect to the United States by Porell (1982) and Canada by Ledent (1980)[4]. Based on Alonso's general theory, Nijkamp and Poot (1987) also analyzed the dynamic properties of generalized special interaction

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[2] Macisco (1993) et al. introduce the seven laws of migration of Ravenstein.

[3] Poot (1986) mentioned this and set the basic concept of the model below, as I introduce in the paper.

[4] Tabuchi (1984), based on the Alonso's general theory ,developed a structurally similar model with a theory of supply and demand interaction. They applied the model to international trade flows and patient flows to hospitals.

models.

When applied to the inter-regional exchange of workers, the model can be formulated in the following manner. To begin with, the out-migration of workers from region (i), M_i, is assumed to be a function of the socioeconomic and demographic characteristics of region (i). However, out-migration is also a function of workers' perception of the other places relative to region (i). For example, the opportunity cost of remaining in region (i) will be high when a move can take place from the region with many friends and relatives to new regions. This leads to the following out-migration equation:

$$(2) \qquad M_{i.} = c_1 O_i R_i^{\nu} e^{\eta_i} \qquad i = 1,\dots,n$$

$$(3) \qquad O_i = \prod_{k=1}^{K} X_{ik}^{\alpha_k} \qquad i = 1,\dots,n$$

where X_{ik} is the individual push factor (k = 1,2,…,K), c_1 is the proportionality constant, and O_i is an index of the combined push factors that will be modeled as a multiplicative function of these factors. R_i is the index of the perceived opportunity cost of remaining in (i) region, with ν being the elasticity of out-migration with respect to changes in the system's demand for migrants. Finally, η_i is an additive disturbance, after a logarithmic transformation, and assumed to be NID(0, σ_η^2). Similarly, in-migration into (j) region, $M_{.j}$, is modeled as

$$(4) \qquad M_{.j} = c_2 D_j A_j^{\mu} e^{\theta_j} \qquad j = 1,\dots,n$$

$$(5) \qquad D_j = \prod_{l=1}^{L} Y_{jl}^{\beta_l} \qquad j = 1,\dots,n$$

Here, c_2 is again a proportionality constant and D_j is an index of the combined pull factors, which is assumed to be a multiplicative function of observable variables. A_j is an index of the relative competitiveness or attractiveness of urban area j, with elasticity μ. When the value of this index is high, this region is likely to have high levels of out-migration and "push" workers into region (j). The disturbance term θ_j is assumed to be NID(0,σ_θ^2).

Given the supply of migrants in (i) region (i =1,2,…,n) and the demand for migrants in (j) region (j =1,2,…,n), the allocation of migrants depends on the permanent move between region (i) and (j), measured by index F_{ij}, which is related to the generalized costs of the move that includes removal costs, physic costs, and search costs. Then, F_{ij} can be arranged in a generally non-symmetric matrix F of which each element is a multiplicative function of interaction variables that measure the costs of migration, so that

$$(6) \qquad F_{ij} = \prod_{g=1}^{M} H_{m_{ij}}^{\varphi_g} \qquad M = 1,\dots,n \times (n-1); \quad i,j = 1,\dots,n \qquad i \neq j$$

with H_{mij} being one of the observable factors involved, m = 1, 2,…,M.

For given $M_{i.}$ and $M_{.j}$, the allocation of migrants M_{ij} (i, j =1,2,…, n; i ≠ j) is assumed to satisfy[5]

$$(7) \qquad M_{ij} = cM_{i.}M_{.j}F^{\omega}{}_{ij}e^{\varepsilon_{ij}} / (R_i A_j) \qquad\qquad i \neq j$$

If out-migration from any (i) regions and in-migration to any (j) regions are independent, the RHS of (7) would be equal to a constant. Instead, in (7) it is assumed that the interaction between M_i, and $M_{.j}$ is proportional to F_{ij}, while the division by the product of the system variables takes into account the interdependencies of the flows. Equation (7) also incorporates stochastic disturbances that, after taking logarithms and using cross-section data, can also be assumed to be spherical with $\varepsilon_{ij} \sim NID(0,\sigma_\varepsilon^2)$ and independent of (η_i,σ_j). The parameter c is a proportionality constant. In practice, the system variables R_i and A_j are not observed, but I define them as weighted average later.

It should be noted that the model pertains to a closed system: external influences are not explicitly taken into account in the definition of the system variables. The importance of such influences on inter-regional labor migration depends on whether some flows within the system are overwhelming to external effects, such as the incidence of international migration. One way to introduce an open system is to augment the migration matrix with a column and row for "the rest of the world," but data limitations and difficulties in defining the characteristics of this alternative location make this an unattractive solution. Subjecting equations (2) and (4) into (7) and taking the logarithm yields an equation that resembles the conventional single-equation gross migration models:

$$(8) \quad \log(M_{ij}) = \log c + \omega \log F_{ij} + \sum_{k=1}^{K} \alpha_k \log X_{ik} + (\nu - 1)\log R_i + \sum_{l=1}^{L} \beta_l \log Y_{jl} + (\mu - 1)\log A_j + \xi_{ij}$$

$$c = c_1 c_2,\ \xi_{ij} = \eta_i + \theta_j + \varepsilon_{ij}, \qquad i, j = 1,\ldots,n \qquad i \neq j$$

Further, R_i and A_j are also specified in equations (8) and (9), and the simultaneous equation system from (8) to (10) forms the model that is empirically tested in this study. Some researchers ignore the allocation of migrants into migration costs, in-migration and out-migration, but concentrate solely on in-migration or out-migration. However, this approach has the disadvantage that internal consistency (total in-migration equals total out-migration) is not guaranteed. The estimated results reported in section III confirms that the data for Vietnam provide further support that intermediate values for both ν and μ are statistically most satisfactory.

Model estimation technique

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5 Poot (1986) set the LHS as $M_{ij}/\hat{F}_{ij}$. However, here, I set the variable $\hat{F}_{ij}$ on the RHS and estimate its coefficient to consider the change of the coefficient among 1989, 1999, and 2009.

Here, I present the detailed procedure for the estimation of the migration model with equation (8).

First step: Estimate the gravity model (1) is using equation (6) and represent the estimated value of F_{ij} as $\hat{F}_{ij}$.

Second step: Determine the initial value of system variables (R_i, A_j), and use $\hat{F}_{ij}$ to estimate the migration equation log (M_{ij}) using the ordinal least squares method. The estimated values of M_{ij} are represented by $\hat{M}_{ij}$.

Third step: Obtain the estimated value of $\hat{M}_{i.}$, $\hat{M}_{.j}$ from the condition $\sum_{j=1}^{n} M_{ij} = M_{i.}$ *and* $\sum_{i=1}^{n} M_{ij} = M_{.j}$ Then, calculate the updated value of $\hat{R}_i$, $\hat{A}_j$ from the following equations.

$$(9) \qquad R_i = c\sum_{j=1}^{n} M_{.j} A_j^{-1} F^{\omega}{}_{ij} e^{\varepsilon_{ij}} \qquad j \neq i \qquad i = 1,\ldots, n$$

$$(10) \qquad A_j = c\sum_{i=1}^{n} M_{i.} R_i^{-1} F^{\omega}{}_{ij} e^{\varepsilon_{ij}} \qquad j \neq i \qquad j = 1,\ldots, n$$

Last step: Use $\hat{R}_i$, $\hat{A}_j$ to estimate the parameters (α_k, β_l) in the migration equation (8). For this purpose, the ordinary least squares (OLS) method is used until the log likelihood function of log (M_{ij}) takes the maximized value.

III. Estimation results

The result of the gravity model estimated by equation (1) from the 1989 census is presented in Table 1. Then, the estimated value, $\hat{F}_{ij}$, is put in equation (6) to calculate the migration model of equation (8). With regard to the variables in Table 1, Distance (i, j) states the logarithm of the distance between regions (i) and (j). Labor population (i) 84 and Labor population (j) 94 presents the logarithm of the population of regions (i) and (j) in 1984 and 1989, respectively. All estimated parameters, including regional dummy variables of the capital of Vietnam, Hanoi, and the largest commercial city, Ho Chi Minh, are significant. Further, the signs of parameters are as expected—$\alpha > 0$, $\beta > 0$, $\gamma < 0$.

< Table 1 Result of the gravity model >

The result of the regional labor migration model estimated by equation (8) is presented in Table 2 below.

< Table 2 Result of the regional labor migration model, 1984–1989 >

With regard to the variables in Table 2, the estimated value of $\hat{F}_{ij}$ as the logarithm of the estimated variable of the migration cost function is included in equation (6). The variables of the out-migration function of equation (2) are Agricultural labor force (i) 84, Food production per capita (i) 84, and Opportunity cost (R_i). As shown in the table, the sign of the first coefficient of Agricultural labor force (i) 84 is positive; this shows that the larger the population in the agricultural sector, the greater the out–migration that occurs under the high pressure of labor supply in the regional market. The second coefficient of Food production per capita (i) 84 is negative. According to the theory of development economics, this is rational. This is because, the lower the amount of food a person in the region has, the greater the out-migration occurs as people seek to satisfy their food needs.

In the same manner, the variables of the in-migration function in equation (4)—Per capita income 89 (j), Increase in labor force 84–89 (j), and Amenity (A_j)—are interpreted. The sign of the first coefficient of Per capita income 89 (j) is positive; this indicates that the higher average income in the region, the greater the in-migration in the region as people seek high income. The second coefficient of Increase in labor force 84–89 (j) is a kind of instrumental variable to determine how easily people can obtain a job in the market. For this, the unemployment rate is the most preferred variable. However, in Vietnam, data on the unemployment rate by province is not available for 1989. Here, I assume that the more the labor population increases in a certain year—here, during five years (from 1984 to 1999)—the more opportunity people might have for obtaining jobs in subsequent years. Although the variable increase in labor force 84–89 (j) is alternatively used for measuring unemployment rate and is the second best, the sign of the coefficient is positive and statistically significant at the one percent level.

The interpretation of the invisible variables of Amenity (A_j) and Opportunity cost (R_i) could be available from a relative comparison between them. As I show in equation (8), the coefficient plus one implies that the elasticity of Amenity (μ) or Opportunity cost (ν) respectively for in- and out-migration. Then, from Table 2, μ is 1.094 and larger than ν, which is 0.918. The Amenity variable calculated by the system approach here has a relatively larger influence on the in-migration function than Opportunity cost variables on the out-migration function. With regard to the contribution to migration in Vietnam during the period 1984–1989, the cost, in–migration, and out-migration functions are 0.24, 0.48, and 0.28, respectively[6].

Lastly, I interpret the estimation results of the dummy variables in Table 2. In this model, I use two types of regional dummy variables. The first type is the regional dummy variable where labor migrates from all national provinces into a certain province such as Hanoi, Ho Chi Minh, Dak Lak, and Dong Nai provinces. Interestingly, among these four regional dummy variables, the large populated city of Hanoi and Ho Chi Minh are not significant. On the other hand, Dak Lak province located in the southeast and the new industrialized province of Dong Nai are significant. This implies that in the initial stages of Vietnamese innovation "Doi moi," which began from 1986 onward, there has been an inflow of people into Dak Lak province seeking jobs in agriculture and into Dong Nai province seeking jobs in industrial sectors. The second type of dummy variable is a two-way regional dummy variable to estimate the inflow and outflow of migrations between these two regions. For example, this two-way regional dummy between Hanoi and its neighboring provinces—Hai Phong, Vinh Phuc, Ha Bac, Ha Son Binh, Hai Hung, Thai Binh, and Ha Nam Ninh—is significant. In the same manner, the two-way regional dummy between Ho Chi Minh and its neighboring provinces—Song Be, Dong Nai, Long An, Tay Ninh, and Baria Vung Tau—are significant. These findings imply that in the initial stage of the Doi moi era of Vietnamese economic development, there was a positive outflow and inflow of migration between the two largest cities—Hanoi and Ho Chi Minh—and certain neighboring provinces, but not all nationwide provinces[7]. This is probably partially because economic infrastructure like roads, railway, as well as airport facilities were so poor that people felt uncomfortable to migrate from and to distant provinces from the two largest cities, Hanoi and Ho Chi Minh. This implication is consistent with other findings, as will be seen later that the influence of the two types of regional dummy variables, regional dummy variable from all national provinces into Hanoi, Ho Chi Minh and two-way regional dummy variable between Hanoi, Ho Chi Minh and certain neighboring provinces increased in 1999 and 2009.

Next, I present the results of regional labor migration estimated by equation (8) from Census 1999 in Table 3 and Census 2009 in Table 5 below. In the results presents in Tables 3 and 5, as mentioned above, a sixty-province matrix data set was originally created to compare the results of these results between Census 1999 and Census 2009. Here, as the observations are expressed as the combination between provinces, the sampling size is 3,540 (60 × 59).

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[6] Based on estimation equation (8), the contribution of the cost, in–migration, and out-migration functions to migration is calculated as the weighted average ratio of the absolute value, respectively, $\omega \log F_{ij}/\log M_{ij}$, $\Sigma|\alpha_k|\log X_{ik} + |\nu -1|\log R_i) /\log M_{ij}$, $\Sigma|\beta_l|\log Y_{il} + |\mu -1|\log A_i) /\log M_{ij}$, (i,j = 1…n). For convenience in comparing them, the three values are weighted to be one in sum.

[7] Note that the sign of the two-way regional dummy between Hanoi and its neighboring provinces is negative. It means that there exists a positive outflow and inflow of migration between the two largest cities—Hanoi and Ho Chi Minh—and certain neighboring provinces. However, its impact is not so large and less than the average impact of migration model expressed with equation (8).

< Table 3 Result of regional labor migration model I 1994–1999 >

In the 1990s, the Vietnamese economy was booming and there was a high annual economic growth rate, with an average of 18.17%. There was investment promotion in almost every province, with the creation of industrial zones and new bank branches opening up in every province. This resulted in providing greater business opportunities, particularly in Ho Chi Minh that expanded its economic power to neighboring provinces with the out-migration of laborers. Also power of out migration into other provinces increased with the sign of the coefficient of Agricultural labor force (i) 94 is positive, and the coefficient of Food production per capita (i) 94 is negative. It is these effects that caused a decrease in the influence of the in-migration function on the total migration function.

In the same manner as in Table 2, the variables of the in-migration function of equation (4)—Per capita income 99 (j), Increase of labor force 94–99 (j), and Amenity (A_j) are interpreted, respectively. The sign of the coefficient of Per capita income 99 (j) turned out to be negative. Note that this does not imply that labor migrated for "low" income gains or that the out-migration function had an excessive influence on the in-migration function. This is because in this period, there was migration from a high-wage earning region, like Ho Chi Minh, to a relatively low-wage earning region. This causes the value of the coefficient of Per capita income 99 (j) to be negative. This interpretation is also consistent with the fact that the coefficient of Increase of labor force 94–99(j) is still statistically significant, but the value decreased to almost zero.

In contrast to the weakness of the in-migration function on total migration, the influence of the cost and out-migration functions increased. The contribution of the cost, in–migration, and out-migration functions to total migration in Vietnam during the period 1994–1999 is 0.29(21%), 0.23(-52%), and 0.48(74%), respectively[8].

Lastly, I discuss the implication of two types of regional dummy variables on the estimated results. As seen in Table 3, among the four regional dummy variables where labor migrates from all national provinces into Hanoi, Ho Chi Minh, Dak Lak, and Dong Nai provinces, the dummy variables of the large populated cities of Hanoi and Ho Chi Minh are significant, but negative. Coincidently, the two-way regional dummy variables between Ho Chi Minh and its neighboring provinces are positive and significant. This is in contrast with the results of the two-way regional dummy variable between Hanoi and its neighboring provinces, which are insignificant. This finding shows that a new economic geographic expansion began from Ho Chi Minh and dynamically flowed into surrounding regions in the end of the 1990s. For a clearer estimation, the labor migration model in Table 3 was re-estimated with a couple of two-way dummy variables in Table 4.

< Table 4 Result of regional labor migration model II 1994–1999 >

[8] The percentage change in parenthesis shows the contribution compared to that in 1989.

In this extension model, two-way dummy variables were used only between Ho Chi Minh and its neighboring provinces—Tay Ninh, Binh Duong, Long An, and BariaVungtau provinces. Each two-way dummy variable measures two directions of migration, for example, from Ho Chi Minh to BariaVungtau and from BariaVungtau to Ho Chi Minh. As evident from Table 4, the effect and absolute value of the coefficient of dummy valuables from Ho Chi Minh to BariaVungtau is 1.9 times larger than that of the opposite-direction dummy variable from BariaVungtau to Ho Chi Minh. BariaVungtau province is located in the southeast and at approximately 90 km from Ho Chi Minh. This province is famous for off shore oil production and sightseeing as it has beautiful beaches. In the same manner, the value of the coefficient of dummy valuables from Ho Chi Minh to Binh Duong—located at the northern border of Ho Chi Minh—is 1.87 times larger than that of the opposite-direction dummy variable. The national regional dummy variables where labor migrates from all national provinces into Dong Nai province located on the eastern border of Ho Chi Minh is also significant. These findings show that in the 1990s, with labor outflow, Ho Chi Minh and its neighborhood provinces such as Binh Duong, Dong Nai, and BariaVungTau witnessed the establishment of numerous manufacturing factories. Currently, Dong Nai has the most industrial parks in Vietnam.

The results of regional labor migration estimated by equation (8) from Census 2009 are presented in Table 5 below.

< Table 5 Results of the regional labor migration model 2004–2009 >

As shown in Table 5, the two variables of the in-migration function of equation (4), Per capita income 09 (j) and Increase in labor force 04–09 (j) are not insignificant. This shows that the influence of in-migration on the migration function continued to decrease from 1999 onward. This is because, as mentioned above, the Vietnamese economy boomed and achieved the highest stock market value in 2006 and then the real estate market bubble burst and disappeared. Under the national recession, the economic attractiveness of most provinces weakened, and labor migration was less influenced by high income and job opportunities. On the other hand, the pressure of outflow of labor from provinces increased. This view is consistent with the finding that the absolute value of the coefficient of the out-migration function of equation (2), for example, Food production per capita (i) 04 increased from 0.45 in 1999 to 0.96 in 2009. Moreover, the fact that regional dummy variables for labor migration from all national provinces into Hanoi and Ho Chi Minh have a positive value and are significant. Thus, it can be concluded that this estimation result is consistent with the reality of the Vietnamese economy that under the world economic recession, labor—particularly those who lost their jobs in local provinces—moved into large populated cities. Thus, the amount of labor inflow to Hanoi and Ho Chi Minh surpassed the average amount of national migration. Last, the results of the two-way regional dummy variable between Ho Chi Minh and its neighboring provinces are positive and significant. This proved that there was a stronger inflow and outflow of labor among provinces in the south economic region around Ho Chi Minh.

Further, the contribution of the cost, in–migration, and out-migration functions to total migration in Vietnam during the period 2004–2009 is 0.22 (-21%), 0.13 (-41%), and 0.63(33%), respectively[9].

IV. Dynamic change in labor migration in Vietnam for the 20–year period from 1989–2009

In this chapter, based on the results of the estimation of labor migration, I design and estimate the long-term labor migration function using the error correction model (ECM). This function provides the parameter estimation of the adjustment coefficient to measure the speed of convergence. Before the estimation of the ECM, I draw figures of rank size rule for 20 years from 1989 to 2009, and show the dynamic changes in the population scale and population rank in provinces in Vietnam.

In the figure, the horizontal lines show the population rank and are arranged with ascending order by rank size where the largest populated province is on the left and the smallest populated one is on the right. The vertical line shows the value of the population of each province multiplied by its rank on the horizontal line.

< Figure 1 Rank size of provinces for 1989, 1999, and 2009 >

In the figure, because the number of provinces increased from 44 in 1989 to 61 in 1999, and to 63 in 2009, it is evident that the number of middle- and small-sized population provinces increased on the right-hand side of the figure. However, there was no intersection of rank size for 1989, 1999, and 2009. In contrast, there was some cross section on the left-hand side, and this shows that there was a substantial change in the relation of ranks among highly populated provinces. In order to observe which provinces underwent a dynamic change in its population, the rank size for 1989, 1999, and 2009, respectively, is displayed.

< Figure 2 Rank size of provinces 1989 >

< Figure 3 Rank size of provinces 1999 >

< Figure 4 Rank size of provinces 2009 >

[9] Percent change in the parenthesis shows of contribution compared with that in 1999.

Comparing Figures 1 and 2, it is evident that in the decade from 1989 to 1999, the ranks of provinces such as Dong Nai (from 18 to 7), Long An (from 24 to 20), and BariaVungtau (from 44 to 40) increased with relatively high speed.

In the same manner, a comparison of Figures 2 and 3 shows that in the decade from 1999 to 2009, the ranks of areas such as Hanoi (from 4 to 2), Hai Phong (from 12 to 7), and Dong Nai (from 7 to 5) continued to increase. Further, the ranks of Binh Duong (from 46 to 16) and Lam Dong (from 61 to 28) increased rapidly. These findings show that under such dynamic changes in population, the entire Vietnamese population was concentrated in large cities and provinces. At the same time, the difference in population among middle- and small-populated province was dismissible. This is evident from the Lorenz curve of population presented below. In the figure, the provinces are ordered from the least to the most populated province on the horizontal axis.

< Figure 5 Lorenz curve of population of provinces for 1989, 1999, and 2009 >

In the figure, because these curves are going downward and the distance between the Lorenz curve and the 45-degree line increases on the right side, it is evident that the population concentrated in large cities and provinces such as Ho Chi Minh, Hanoi, Thanh Hoa, Nghe An, Dong Nai, An Giang, and Hai Phong in descending order. In contrast, on the left-hand side of the figure, it is evident that the distance between the Lorenz curve and the 45-degree line is shrinking. This is consistent with the abovementioned conclusion that there was narrowing in the gap in population size among small- and medium-sized provinces.

Next, to study these dynamic charges in the population of Vietnamese provinces, the long-term labor migration function was combined with ECM in the following manner. The distribution of stochastic error ε_t is assumed to follow a normal distribution.

$$\triangle Y_t = \gamma\beta \triangle X_t - \gamma(Y_{t-1} - \alpha - \beta X_{t-1}) + \varepsilon_t \qquad (11)$$

$$\triangle Y_t = Y_t - Y_{t-1}$$

Here, the coefficient of error term, $-\gamma$, is expected to be negative.

If $Y_{t-1} - \alpha - \beta X_{t-1} \leqslant 0$, then $\triangle Y_t = Y_t - Y_{t-1} \gtreqless 0$.

In this case, when the error correction term, $Y_{t-1} - \alpha - \beta X_{t-1}$, is negative, then Y_t increases and $\triangle Y_t = Y_t - Y_{t-1} > 0$. Moreover, from the estimated value of the coefficient of the error term, we can measure the convergence speed in the long term. For example, when $\gamma = 0.8$, it implies that the model could converge 80% in the current year and 96% in the subsequent year. I used the labor migration model (8) and its residual $\hat{\varepsilon}_{t-1}$ in Table 2 for the ECM estimation. The result is presented in Table 6. Note that, here, there is a ten-year time span and variables 1999 (t) and 1989 (t – 1) are expressed.

< Table 6 Result of ECM for 1989–1999 >

The estimated coefficient of the error term is negative, −0.534; then, the long-term labor migration function converges. It converges around 90% by 2020 and 99% by 2050. The long-term migration model for a twenty-year span by putting 2009 (t) and 1989 (t – 1). Interestingly, the coefficient of error term −0.530, is almost the same value, −0.534, in Table 6. This shows that, even though there was dynamic change in province population during 1989–2009, as we saw in Figure 1, there exists a long-term migration function that converges with a speed of approximately −0.53. With these dynamic provincial population changes, it was shown that there is in- and out-migration between Ho Chi Minh and its peripheral provinces in south Vietnam. With regard to the relationship between long-term migration and the two-way regional dummy variables, for example, the in- and out-migration between Ho Chi Minh and its peripheral provinces in south Vietnam is significant for long-term migration. Because when the residual $\hat{\varepsilon}_{t-1}$ of the migration equation model (4) is used without two-way dummy variables in the right column of Table 2, and the ECM estimation is implemented, the coefficient of the error term becomes positive, 0.63, then the migration model does not converge in the long term.

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V. Conclusion

Labor migration, as mentioned in the introduction in this paper, is related to multiple aspects such as demographic, sociological, and economic factors. In this sense, it can be said that migration is a social phenomenon. Analyzing only from the economic viewpoint is merely like skimming the surface of the sea without diving into the depths. It is akin to describing “pieces of icebergs” on the sea. In developing countries, labor migration triggers structural changes in industrial labor and also has a large impact on the economy. Therefore, from the sociological viewpoint, researchers are expected to design and estimate the precise cause-and-effect relations between economic factors and migration as a social phenomenon. In this study, based on Poot's model (1986), the methods for studying multi-intertemporal analysis in 1989, 1999, and 2009 were extended. It was indicated that during these 20 years, (1) there was a statistically significant relationship of local migration between Ho Chi Minh and its peripheral provinces in south Vietnam underlying the dynamic change in population in all provinces in Vietnam. (2) Under economic recession at the end of the 1990s, with the deepening of this migration relation between Ho Chi Minh and its peripheral provinces, there was a reduction in the influence of in-migration factors of large cities like Hanoi and Ho Chi Minh. (3) At the same time, coincidently, industrialization in Binh Duong and Dong Nai provinces in the south had begun to take off. Therefore, out-migration from Ho Chi Minh to its peripheral provinces prevailed. (4) Based on these results, the ECM of the labor function was calculated and it was revealed that Vietnamese labor migration is converging in the long-term with a negative coefficient of the error term -0.53. Further, the long-term model also provided interesting evidence that in Vietnam, a nationwide migration and regional development process and migration coexists. Although geographical development appears complicated, the underlying phenomenon is that a large city influences peripheral regions to form new and emerging developing cities. The existence of long-term labor migration in Vietnam makes way for the possibility of expressing and explaining dynamic labor migration in Vietnam through a long-term model. For this purpose, a data set of four different time periods, like 1989, 1999, 2009 and 2019 is required to conduct an integration test. Another direction for future research is to conduct a deeper analysis from micro data to ascertain whether the results are consistent with those obtained here from aggregated data.

References

(1)Data

Vietnam Population Census 1989 , Central Census Steering Committee, Ha Noi, 1991.

—Volume 1 "Population by age and sex"

—Volume 1 "Migration"

Population and Housing Census Vietnam 1999, General Statistics Office, Ha Noi, 2001.

The 2009 Vietnam Population and Housing Census, General Statistics Office, Ha Noi, 2010.

Statistical Year Book 1994, 1996, 1999, 2004,2006, 2009, Statistical Publishing House, Hanoi.

Statistical Data of Agriculture, Forestry and Fishery 1985-1995, Statistical Publishing House, Ha Noi, 1996.

(2)Paper and book

Anh, T. S., Knodel, J., Lam, D. and Friedman, J. (1998) "Family Size and Children's Education in Vietnam," *Demography*, 35 (1), pp.57-70.

Baltagi, B. H. (1999) *Ecomometrics 2 nd revised edition*, Springer.

Barro, R. J. and Sala-I-Martin, X. (1995) *Economic Growth*, Mcgrow-Hill.

Breusch, T. and Pagan, A. (1979) “ A simple Test for Heteroscedasticity and Random Coefficient Variation,” *Econometrica*, 47, pp.1287-1294.

Davidson,R and Mackinnon, J.G.(1984) “Model Specification Tests Based on Artificial Linear Regression,” *International Economic review*, 25(2), pp.485-502.

------------------ (1993) *Estimation and Inference in Econometrics*, Oxford University Press.

Fujita,M., Krugman, P. and Venables, A. J. (1999) *The Spatial Economy*, The MIT Press.

Godfrey, L. G. (1978) ”Testing for Multiplicative Heteroscedasticity,” *Journal of Econometrics*, 16, pp.227-236.

Greene, W. H. (1997) *Econometric Analysis 3rd Edition*, Prentice Hall.

Huriot,J. M. and Thisse,J. F. (2000) *Economics of Cities*, Cambridge University Press.

JICA (2000) *Tokyo Workshop for The Joint Viet Nam-Japan Research, Phase3, 26-27 July, Tokyo* , Japan International Cooperation Agency.

Macisco, Jr., John J., and Edward T. Pryor, Jr.(1963) “A Reappraisal of Ravenstein's "Laws" of Migration: A Review of Selected Studies of Internal Migration in the United States”, *The American Catholic Sociological Review*, 24(3), pp. 211-221.

Nguyen, D. H. (1997) “ A Socioeconomic Analysis of the Determinants of Fertility: The Case of Vietnam,” *Journal of Population Economics*, 10(3), pp.251-71.

Nijkamp,P. and Poot, J. (1987)”Dynamics of Generalized Spatial Interaction Models,” *Regional Science and Urban Economic*s, 17, pp. 367-390.

Poot, J. (1986) “A System Approach to Modeling: The Inter-Urban Exchange of Workers in New Zealand”, *Scottish Journal of Political Economy*, 33, pp.249-274.

Ravenstein, E. G. (1889)” "Laws" of Migration: A Review of Selected Studies of InternalMigration in the United States”, *Journal of the Royal Statistical Society*,52(2), pp. 241-305

Smith,T. E. and Hsieh,S. H. (1997) “ Gravity-Type Interactive Markov Models--Part I: A Programming Formulation of Steady States,” *Journal of Regional Science*, 37(4), 653-682.

Stimson,R.,Stouch, R.R. and Njikamp, P. (2011) *Endogenous Regional Developmen*t, Edward Elger Publishing Limited.

Suits, D. (1984) “Dummy Variables : Mechanics V. Interpretation,” *The Review of Economics and Statistics*, 66, 177-180.

Tabuchi, T. (1984) “The Systemic Variables and Elasticities in Alonso's General Theory of Movement,” *Regional Science and Urban Economics*, 14, pp.249-264.

Thursby, J.G. and Schmidt, P. (1977) “Some Properties of Tests for Specification Error in a Linear Regression Model”, *Journal of the American Statistical Association* ,72, pp.635-641.

Appendix List of province in 1984, 1999, 2009.

1984		1999		2009	
1	Ha Noi	1	TP Ha Noi	1	TP Ha Noi
2	Ho Chi Minh	2	TP Hai Phong	2	Ha Giang
3	Hai Phong	3	Ha Tay	3	Cao Bang
4	Cao Bang	4	Hai Duong	4	Bac Kan
5	Ha Tuyen	5	Hung Yen	5	Tuyen Quang
6	Lang Son	6	Ha Nam	6	Lao Cai
7	Lai Chau	7	Nam Dinh	7	Dien Bien
8	Hoang Lien Son	8	Thai Binh	8	Lai Chau
9	Bac Thai	9	Ninh Binh	9	Son La
10	Son La	10	Ha Giang	10	Yen Bai
11	Vinh Phu	11	Cao Bang	11	Hoa Binh
12	Ha Bac	12	Lao Cai	12	Thai Nguyen
13	Quang Ninh	13	Bac Can	13	Lang Son
14	Ha Son Binh	14	Lang Son	14	Quang Ninh
15	Hai Hung	15	Tuyen Quang	15	Bac Giang
16	Thai Binh	16	Yen Bai	16	Phu Tho
17	Ha Nam Ninh	17	Thai Nguyen	17	Vinh Phuc
18	Thanh Hoa	18	Phu Tho	18	Bac Ninh
19	Nghe Tinh	19	Vinh Phuc	19	Hai Duong
20	Binh Tri Thien	20	Bac Giang	20	TP Hai Phong
21	Quang Nam-Da Nang	21	Bac Ninh	21	Hung Yen
22	Nghia Binh	22	Quang Ninh	22	Thai Binh
23	Phu Khanh	23	Lai Chau	23	Ha Nam
24	Thuan Hai	24	Son La	24	Nam Dinh
25	Gia Lai-Kon Tum	25	Hoa Binh	25	Ninh Binh
26	Dac Lac	26	Thanh Hoa	26	Thanh Hoa
27	Lam Dong	27	Nghe An	27	Nghe An
28	Song Be	28	Ha Tinh	28	Ha Tinh
29	Tay Ninh	29	Quang Binh	29	Quang Binh
30	Dong Nai	30	Quang Tri	30	Quang Tri
31	Long An	31	Thua Thien Hue	31	Thua Thien Hue
32	Dong Thap	32	TP Da Nang	32	TP Da Nang

1989 年		1999 年		2009 年	
33	An Giang	33	Quang Nam	33	Quang Nam
34	Tien Giang	34	Quang Ngai	34	Quang Ngai
35	Ben Tre	35	Binh Dinh	35	Binh Dinh
36	Cuu Long	36	Phu Yen	36	Phu Yen
37	Hau Giang	37	Khanh Hoa	37	Khanh Hoa
38	Kien Giang	38	Kon Tum	38	Ninh Thuan
39	Minh Hai	39	Gia Lai	39	Binh Thuan
40	Vung Tau-Con Dao	40	Dak Lac	40	Kon Tum
		41	TP Ho Chi Minh	41	Gia Lai
		42	Lam Dong	42	Dak Lak
		43	Ninh Thuan	43	Dak Nong
		44	Binh Phuoc	44	Lam Dong
		45	Tay Ninh	45	Binh Phuoc
		46	Binh Duong	46	Tay Ninh
		47	Dong Nai	47	Binh Duong
		48	Binh Thuan	48	Dong Nai
		49	Ba Ria-Vung Tau	49	Ba Ria-Vung Tau
		50	Long An	50	TP Ho Chi Minh
		51	Dong Thap	51	Long An
		52	An Giang	52	Tien Giang
		53	Tien Giang	53	Ben Tre
		54	Vinh Long	54	Tra Vinh
		55	Ben Tre	55	Vinh Long
		56	Kien Giang	56	Dong Thap
		57	Can Tho	57	An Giang
		58	Tra Vinh	58	Kien Giang
		59	Soc Trang	59	T.P.Can Tho
		60	Bac Lieu	60	Hau Giang
		61	Ca Mau	61	Soc Trang
				62	Bac Lieu
				63	Ca Mau

Table1 Result of gravity model

Variables	
Distance(i, j)	−1.12734***
	(−32.32)
Labor population (i) 84	0.8660***
	(19.26)
Labor population (j) 89	0.3009***
	(6.52)
Hanoi(j)	0.5612**
	(2.13)
Ho Chi Minh (j)	1.6155***
	(6.27)
Adjusted R square	0.4805
Number of observation	1560

***, ** and * are significance of 1%, 5%, and 10%, respectively.

Table2 Result of g regional labor migration model 1984 - 1989

Variables		Two way- regional dummy variable	
Constant	−10.7763***	Hanoi−Hai Phong	−0.8769
	(−9.57)		(−1.20)
$\hat{F}_{ij}$	0.9891***	Hanoi−Vinh Phuc	−0.7412***
	(33.23)		(−6.35)
Agricultural labor force(i) 84	0.2628***	Hanoi−Ha Bac	−1.0780**
	(4.11)		(−2.06)
Food production per capita(i) 84	−0.3052***	Hanoi−Ha Son Binh	−2.1833***
	(−3.99)		(−6.14)
Opportunity cost(Ri)	−0.03297	Hanoi−Hai Hung	−1.0697**
	(−0. 74)		(−2.52)
Per capita income 89(j)	0.718***	Hanoi−Thai Binh	−0.3315*
	(7.07)		(−1.93)
Increase of labor force 84−89(j)	0.2580***	Hanoi−Ha Nam Ninh	−0.7575*
	(2.95)		(−1.78)
Amenity (Aj)	0.094**	Ho Chi Minh−Song Be	−1.1084***
	(2.07)		(−3.04)
Hanoi	0.2306	Ho Chi Minh−Tay Ninh	−0.9569***
	(1.21)		(−3.25)
Ho Chi Minh	−0.0007	Ho Chi Minh−Dong Nai,	−2.807*
	(−0.036)		(−1.91)
Dak Lak	3.2426***	Ho Chi Minh−Long An	−1.0335***
	(10.89)		(−2.62)
Dong Nai	2.7974***	Ho Chi Minh−BariVungTau	−0.9704***
	(11.99)		(−0.443)
Adjusted R square	0.5486		
Number of observation	1,560		

***, ** and * are significance of 1%, 5%, and 10%, respectively.
White's standard error is calculated in the parenthesis.

Table3 Result of regional labor migration model I 1994 – 1999

Variables		Two way- regional dummy variable	
Constant	1.2299***	Hanoi−Hai Phong	0.9952
	37.85		(0.43)
$\hat{F}_{ij}$	1.0398***	Hanoi – Hung Yen	0.7791
	(37.85)		(0.29)
Agricultural labor force(i) 84	0.4707***	Hanoi−Ha Nam Ninh	0.7061
	(5.76)		(0.34)
Food production per capita(i) 84	−0.4506***	Hanoi−Thai Nguyen	−2.824
	(−9.57)		(−0.11)
Opportunity cost(Ri)	−0.1591***	Hanoi−Vinh Phuc	−0.4260
	(−4.03)		(−0.15)
Per capita income 99(j)	−0.2378***	Hanoi−Bac Giang	−2.162
	(−2.13)		(−0.09)
Increase of labor force 94−99(j)	0.000007***	Hanoi−Bac Ninh	0.080
	(14.52)		(0.02)
Amenity (Aj)	0.0789***	Ho Chi Minh−Binh Duong	2.5390**
	(2.62)		(2.51)
Hanoi	−2.5252***	Ho Chi Minh−Tay Ninh	2.7632***
	(−8.20)		(2.78)
Ho Chi Minh	−2.8970***	Ho Chi Minh−Dong Nai	2.359**
	(−9.59)		(2.151)
Dak Lak	0.10336	Ho Chi Minh−Long An	3.1725**
	(0.51)		(2.32)
Dong Nai	0.5122***	Ho Chi Minh−BariVungTau	2.5134**
	(2.88)		(2.38)
Adjusted R square	0.3812		
Number of observation	3,540		

***, ** and * are significance of 1%, 5%, and 10%, respectively.

White's standard error is calculated in the parenthesis.

Table4 Result of regional labor migration model II 1994 – 1999

Variables		Two direction - regional dummy variable	
Constant	1.5118*	Ho Chi Minh → Tay Ninh	3.4689***
	(1.76)		(59.93)
$\hat{F}_{ij}$	1.00424***	Tay Ninh → Ho Chi Minh	1.9726***
	(38.13)		(10.77)
Agricultural labor force(i) 84	0.4720***	Ho Chi Minh → Binh Duong	3.2507***
	(5.80)		(46.78)
Food production per capita(i) 84	−0.4512***	Binh Duong → Ho Chi Minh	1.7374***
	(−9.59)		(9.29)
Opportunity cost(Ri)	−0.1700***	Ho Chi Minh → Long An	4.1520***
	(−4.25)		(66.43)
Per capita income 99(j)	−0.2310***	Long An → Ho Chi Minh	2.1205***
	(−2.09)		(11.30)
Increase of labor force 94−99(j)	0.000007***	Ho Chi Minh → BariaVungTau	3.2448***
	(15.07)		(37.81)
Amenity (Aj)	0.0660***	BariaVungTau → Ho Chi Minh	1.6813***
	(2.22)		(8.43)
Hanoi	−2.4778***		
	(−8.90)		
Ho Chi Minh	−2.88660***		
	(−10.05)		
Dong Nai	0.5122***		
	(2.88)		
Adjusted R square	0.3818		
Number of observation	3,540		

***, ** and * are significance of 1%, 5%, and 10%, respectively.

White's standard error is calculated in the parenthesis.

Table5 Result of regional labor migration model 2004 – 2009

Variables		Two way- regional dummy variable	
Constant	5.1359***	Hanoi－Hai Phong	1.2428
	(6.30)		(1.18)
$\hat{F}_{ij}$	1.0368***	Hanoi – Hung Yen	1.2921
	(48.75)		(1.20)
Agricultural labor force(i) 84	0.1900***	Hanoi－Ha Nam Ninh	1.9134
	(3.35)		(0.94)
Food production per capita(i) 84	－0.9683***	Hanoi－Thai Nguyen	－0.3700
	(－21.80)		(－0.25)
Opportunity cost(Ri)	－0.2963***	Hanoi－Vinh Phuc	0.1072
	(－8.22)		(0.07)
Per capita income 09(j)	－0.014	Hanoi－Bac Giang	0.2600
	(－0.26)		(0.11)
Increase of labor force 04－09(j)	－0.0044	Hanoi－Bac Ninh	0.5723
	(－1.05)		(0.73)
Amenity (Aj)	0.1703***	Ho Chi Minh－Binh Duong	1.2173
	(5.80)		(0.73)
Hanoi	1.1236***	Ho Chi Minh－Tay Ninh	1.7015***
	(2.89)		(13.12)
Ho Chi Minh	0.8206*	Ho Chi Minh－Dong Nai	1.3908**
	(1.77)		(2.103)
Dak Lak	1.6574***	Ho Chi Minh－Long An	2.6736***
	(7.73)		(4.30)
Dong Nai	0.9005***	Ho Chi Minh－BariaVungTau	1.2486**
	(5.19)		(5.368)
Adjusted R square	0.3812		
Number of observation	3,540		

***, ** and * are significance of 1%, 5%, and 10%, respectively.

White's standard error is calculated in the parenthesis.

Table6. Result of ECM 1989 – 1999

Variables		Two way- regional dummy variable	
$\triangle \hat{F}_{ij}$	1.9332***	Hanoi−Hai Phong	0.9909
	(19.12)		(0.74)
⊿Agricultural labor force(i)	0.0297	Hanoi−Vinh Phuc	1.6748***
	(0.33)		(16.89)
Food production per capita(i)	−0.3473***	Hanoi−Ha Bac	0.9358
	(−5.45)		(0.65)
⊿Opportunity cost(Ri)	0.2042***	Hanoi−Ha Son Binh	0.6903
	(3.02)		(0.53)
⊿Per capita income(j)	0.7658***	Hanoi−Hai Hung	1.0952
	(7.42)		(0.69)
⊿Increase of labor force(j)	−0.6647***	Hanoi−Thai Binh	1.3908
	(−8.89)		(0.67)
⊿Amenity (Aj)	0.022	Hanoi−Ha Nam Ninh	1.1960
	(0.3282)		(0.91)
Error correction term	−0.5347***	Ho Chi Minh−Binh Duong	−0.6870
	(−22.94)		(−1.25)
Hanoi	0.3171	Ho Chi Minh−Tay Ninh	1.2884**
	(1.41)		(2.07)
Ho Chi Minh	0.8225***	Ho Chi Minh−Dong Nai,	1.2140
	(10.70)		(0.97)
Dak Lak	−2.8234***	Ho Chi Minh−Long An	0.9682
	(−10.70)		(0.72)
Dong Nai	−2.6769***	Ho Chi Minh−BariVungTau	−0.059
	(−10.69)		(−0.04)
Adjusted R square	0.5117		
Number of observation	1560		

***, ** and * are significance of 1%, 5%, and 10%, respectively.
White's standard error is calculated in the parenthesis.

Figure1.　Rank size of provinces 1989,1999, 2009

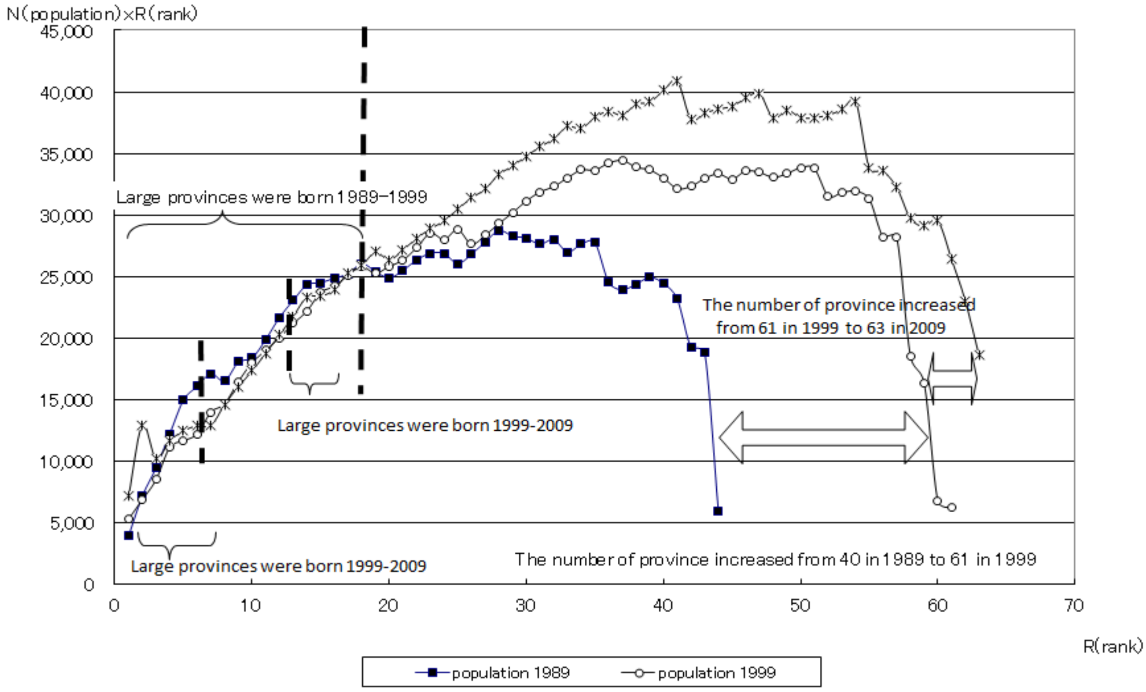

Figure2.　Rank size of provinces 1989

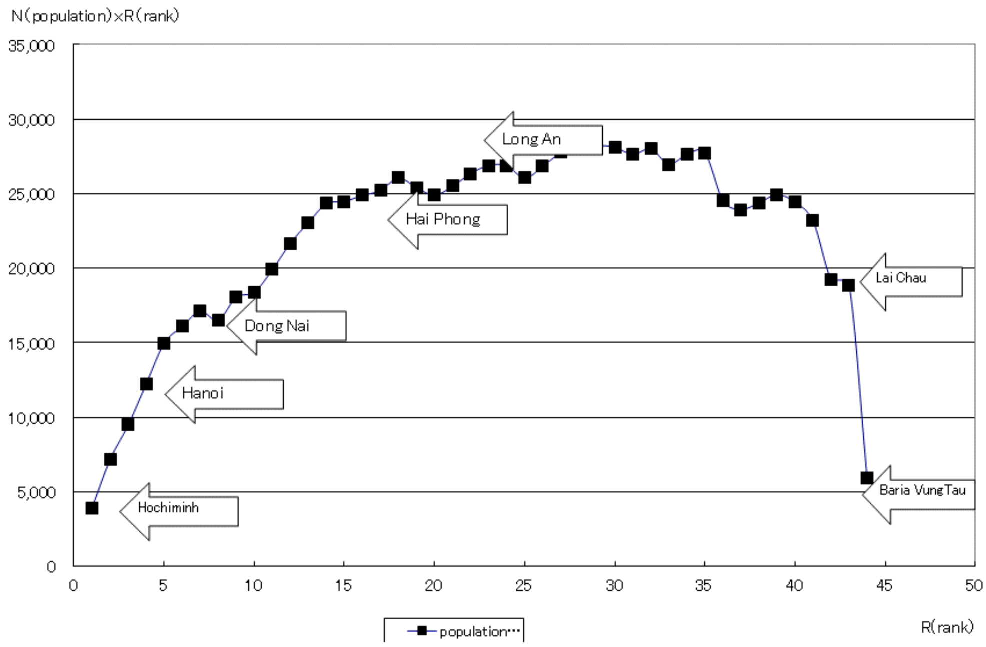

Figure3.　Rank size of provinces 1999

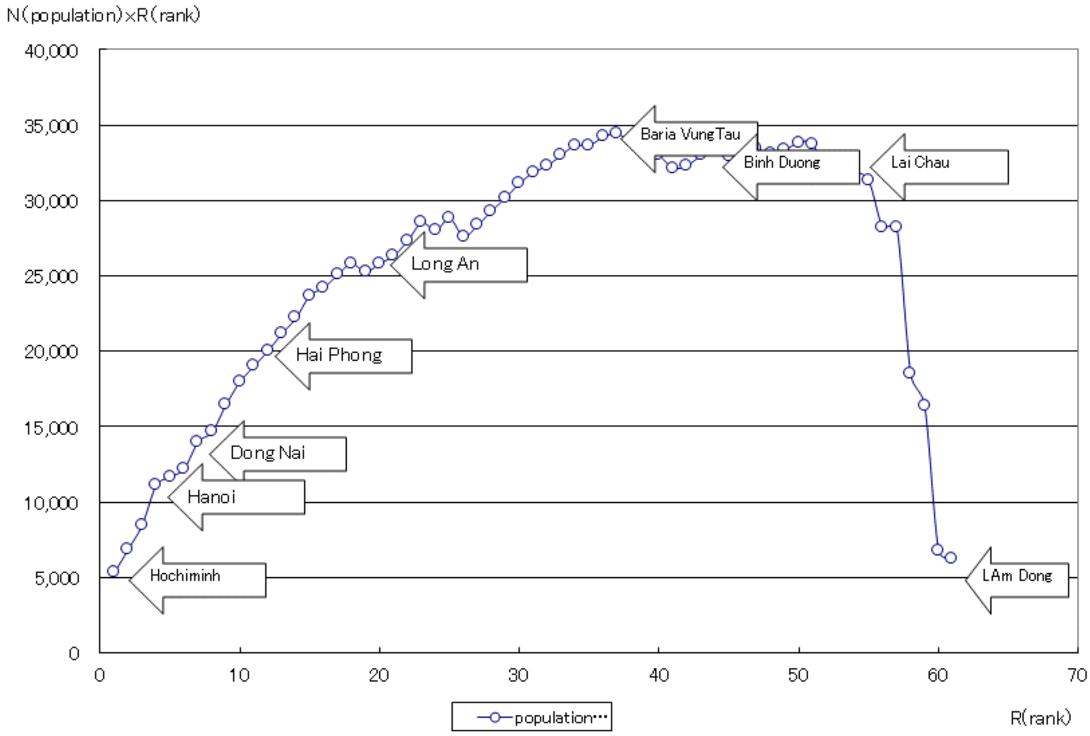

Figure4.　Rank size of provinces 2009

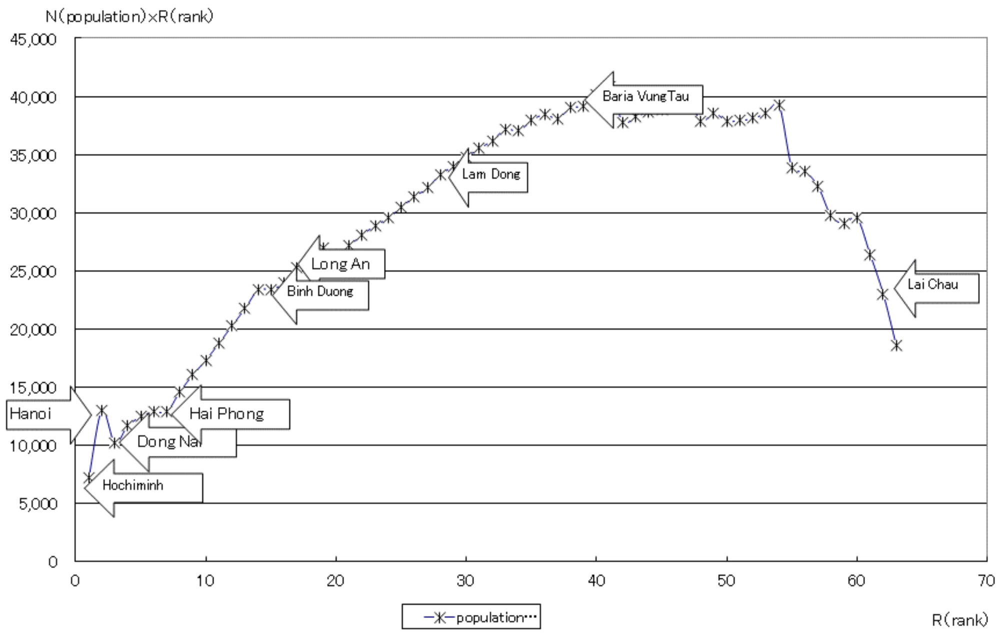

Figure5. Lorenz curve of population of provinces 1989, 1999, 2009