NETWORK ANALYSIS OF INTERNAL MIGRATION IN VIETNAM

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ABSTRACT

This study examines the provincial network structure within Vietnam by investigating migration patterns through the lens of spatial economics and social network analysis. Data were drawn from the Vietnam Household Living Standard Survey covering the period 2012 to 2018, comprising 2,921 observations. A hierarchical clustering method was employed to delineate the structure of internal migration network. The results reveal an asymmetrical racetrack pattern in Vietnam's inter-regional network structure, characterized by two primary clusters-the North and the South. The southern migration cluster exhibits greater prominence, particularly due to a higher proportion of intra-regional migration. Furthermore, within these clusters, analysis of intra-regional network structure indicates an asymmetrical and megalopolitan structure, with Hanoi and Ho Chi Minh serving as the respective hubs of the northern and the southern clusters. This megalopolitan migration network provides new empirical evidence on the importance of economic agglomeration and transportation costs, as emphasized in spatial economics. Moreover, the tendency for intra-regional migration over inter-regional migration underscores the role of social network theory in understanding migration processes. The findings contribute to promote more equitable development among provinces in Vietnam, in alignment with the UN Sustainable Development Goal 10 on reducing inequalities.

Keywords: *Inter-regional network; intra-regional network; migration network; social network analysis; Sustainable Development Goal 10.*

INTRODUCTION

Migration has historically played a crucial role in urban management, especially during the industrialization era, by fostering sustainable economic growth and reducing regional disparities. This aligns with the United Nation's Sustainable Development Goals (SDG 8 and 10) (Giannakis and Bruggeman, 2020). Previous studies on migration primarily delved into the causes and consequences of migration through quantitative and qualitative analyses, focusing on the characteristics of either the origin or destination (Akbari, 2021). These studies highlight various influential factors, including economic opportunities (Borjas et al., 1992; Levy, 2010), immigration policies (Palmer and Pytlikova, 2015), political conditions (Aksoy, 2023), ethnic demographics (Aksoy, 2023), as well as other elements of the origin-destination relationship such as linguistic, cultural, and geographical distances (Expert et al., 2011; Levy, 2010; Windzio, 2018). Nevertheless, the exploration of the migration networks remains relatively nascent (Akbari, 2021), despite their crucial role in shaping migration dynamics (Taylor, 2016). More recently, studies have started to address this gap by examining migration networks (Akbari, 2021; Akın and Dökmeci, 2015; Aksoy, 2023; Windzio, 2018).

Existing literature tends to focus on international migration networks rather than internal migration dynamics, particularly in developing nations (Akbari, 2021; Akın and Dökmeci, 2015; Aksoy, 2023; Windzio, 2018). Internal migration, which affects a larger portion of the population, particularly in non-Western countries, may not be fully captured by studies centered on international migration (Aksoy, 2023). However, internal migration generally involves lower costs and fewer risks (Aksoy, 2023). These lower costs and risks can be attributed to factors such as reduced ethnic demographic challenges, more lenient immigration policies, and fewer cultural and geographical barriers (Aksoy, 2023; Expert et al., 2011; Levy, 2010; Palmer and Pytlikova, 2015; Windzio, 2018).

Despite growing interest in internal migration research, as demonstrated by studies conducted in countries such as Turkey (Akın and Dökmeci, 2015; Aksoy, 2023), China (Lao et al., 2018; Qi et al., 2017), Austria (Pitoski et al., 2021a), Croatia (Pitoski et al., 2021b), and Mexico (Miranda-González et al., 2020), research on migration networks in developing countries remains limited. For countries undergoing industrialization and urbanization, such as Vietnam, examining internal migration networks can provide valuable insights into the economic landscape, potentially promoting agglomeration economies.

This study aims to broaden migration literature by investigating the internal migration network structure of Vietnam. It focuses on analyzing migration flows, identifying key migration hubs, and assessing the interconnectedness of internal migration to uncover regional disparities and propose development strategies for the country. This study addresses gaps in understanding agglomeration economies within spatial economics, as well as the social costs and risks highlighted in sociology. In addition, it offers recommendations for directing public and private investments through a national strategic plan to promote sustainable economic growth across regions.

2. LİTERATURE REVİEW OF MİGRATİON NETWORK STRUCTURE

Early approaches to population migration, such as the gravity model (Beyer et al., 2022), random utility maximization model (Marchal and Naiditch, 2020), and self-selection method (Fuchs, 2023), focused predominantly on bilateral migration flows, analyzing the relationships between specific origin-destination pairs. However, recent migration studies have shifted toward multilateral migration flow analyses, offering a more comprehensive understanding of migration dynamics. These multilateral flows, often referred to as migration networks, exhibit significant dynamism (Gou et al., 2020) and evolve over time due to various factors, including major historical events that have reshaped the global migration networks since the 1990s (Gou et al., 2020). Additionally, interregional migration networks vary significantly among regions depending upon geographic, climatic, and socioeconomic characteristics (Akın and Dökmeci, 2015), which play pivotal roles in shaping migration networks as explored by both economic and sociological theories (Akın and Dökmeci, 2015).

In economics, the New Economic Geography (NEG) theory, rooted in Krugman's Core-Peripheral (CP) model (1991), has emerged as a dominant framework for elucidating regional network structures. The CP model specifically addresses spatial agglomeration within a single region, where economic activities concentrate in core areas driven by centripetal forces. These forces include backward linkages, where firms are gravitate towards regions with high demand for their products, economies of scale, and low transportation costs; and forward linages, where workers are attracted to regions with a diverse range of consumer goods and low living costs (McCann, 2013). This concentration of firms and workers in the core regions reinforces the centrality of economic activities.

Recent developments in NEG theory emphasize firm heterogeneity, multiple-sector analysis, and the inclusion of multiple regions (Gaspar, 2018). Within the multi-regional framework, theoretical models underscore how geography shapes internal migration networks, demonstrating its impact on economic development. Figure 1 illustrates key agglomeration patterns used these models. The Hexagon model, with its two-dimensional hexagonal grid

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ISSN: 2186-8492, ISSN: 2186-8484 Print
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(Ikeda et al., 2014), demonstrates how equidistant regions optimize connectivity and facilitate economic interactions, leading to balanced multi-regional economies. The Monocenter model highlights a core-periphery structure, where economic activities concentrate in a central core while peripheral regions remain less developed (Krugman, 1991). This pattern aligns with models that utilize networks spaced along a real line in a closed economy (Ago et al., 2006). The Megalopolis model depicts multiple interconnected economic centers, reflecting urban hierarchies where several core regions interact closely-similar to equidistant region models (Gaspar et al., 2018; Gaspar et al., 2019; Gaspar et al., 2021). Finally, the Racetrack model showcases a circular distribution of regions, representing Krugman's racetrack economy (Akamatsu et al., 2012; Castro et al., 2012), where reduced transportation costs and economies of scale promote fluid interactions between economic hubs along the circular path. While these models offer valuable insights into city size distributions and urban hierarchies, they often struggle to accommodate historical contingencies and irregular geometrics (Gaspar, 2021).

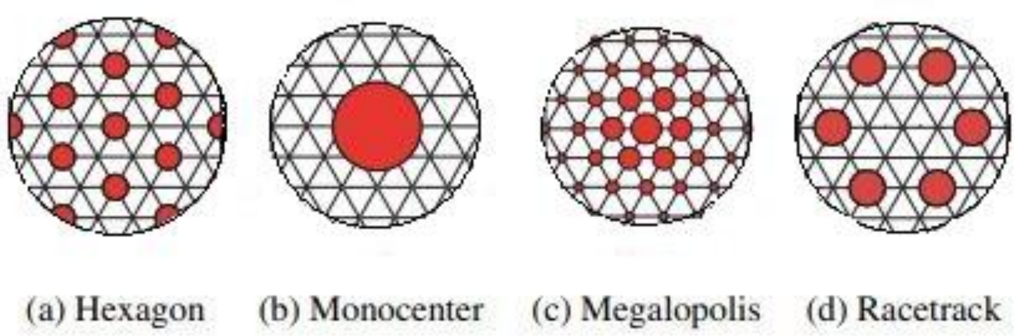

Figure 1: Agglomeration Patterns of Economic Interest

In sociology, various theories have been proposed to explain historical migration patterns. Immigrant transnationalism, for example, has been used to explore early migration flows using the gravity model (Levitt and Jaworsky, 2007). The evolution theory of the European migration system describes the 19th-century migration from Europe to the US, characterized by migration waves and chain-migration dynamics (De Haas et al., 2019). Social Network Theory suggests that migration patterns are influenced by religious and linguistic similarities between migrants and host societies, which facilitate adaption (Kadushin, 2012); (Windzio and Wingens, 2014). Vögtle and Windzio (2016) further argued that, in the presence of hegemonic dominance, immigrant languages and religions may diffuse into host societies, as seen during British and Spanish colonial history and more recent US influences. While these early theories emphasize the influence of migrants' adaptive capacities and the role of immigrant communities, they often fail to capture migration dynamics at a macro-level.

Building on Social Network Theory, Fazito and Soares (2015) proposed a migration network structure that integrates time, speed, and scale to offer a more comprehensive understanding of individual movements between origin and destinations. The influence of Social Network Theory on migration network structure is well-documented (Bilecen et al., 2018; Fazito and Soares, 2015; Gold, 2001), with migration flows conceptualized as "social-spatial networks," where nodes (nations, regions, or provinces) are connected by edges, representing relationships or interactions between them (Barthélemy, 2011; Danchev and Porter, 2018).

Empirical studies have delineated global migration flows (Akbari, 2021; Windzio, 2018), as well as intra-regional migration, particularly in Europe (Windzio et al., 2021). Akbari (2021) demonstrated that global migration flows often converge in hubs such as North America, Western Asia, and Western Europe, where migration clusters form geographically, with intra-cluster migration being more prevalent than inter-cluster migration (Akbari, 2021; Windzio et al., 2021). In developing countries, regional migration network structures display considerable variation. Studies have identified core migration hubs in countries such as Turkey, China, Croatia and Mexico (Akın and Dökmeci, 2015; Lao et al., 2018; Miranda-González et al., 2020; Pitoski et al., 2021b). For instance, Akın and Dökmeci (2015) found that Turkey's migration network is centered around two core areas, Istanbul and Ankara, while Lao et al. (2018) noted that China's regional migration network is structured around three major areas, the Beijing-Tianjin-Hebei Region, the Yangtze River Delta Region, and Pearl River Delta Region. Smaller countries such as Croatia and Mexico exhibit simpler structures, each with a single dominant region (Miranda-González et al., 2020; Pitoski et al., 2021b).

Sociological studies analyzed migration network structures using network-related metrics, particularly centrality degrees, to gauge the connections between nodes through migration flows (Aleskerov et al., 2017). Centrality degrees represent the number of nodes linked to a specific node via migration pathways. Previous studies used raw or normalized migrant counts to analyze network structures, utilizing methods such as community detection (Akbari, 2021; Miranda-González et al., 2020; Pitoski et al., 2021a; Popielarz and Cserpes, 2018) and clustering methods (Akın and Dökmeci, 2015).

In social network analysis, community detection methods include divisive algorithms such as edge betweenness, modularity optimization utilizing algorithms including Louvain, fastgreedy, and InfoMap, as well as spectral algorithms such as spectral graph bipartitioning, among others (Murata, 2010). These approaches have been applied to analyze migration network structures both globally and regionally (Akbari, 2021; Lao et al., 2018; Miranda-González et al., 2020; Pitoski et al., 2021a; Popielarz and Cserpes, 2018). However, these methods exhibit certain limitations, especially due to the variety of partitioning algorithms available, which can make it difficult to select the most appropriate method for a specific analysis (Murata, 2010).

Clustering methods, including hierarchical clustering and k-means clustering, differ in their techniques and measures. For example, Akın and Dökmeci (2015) employed hierarchical clustering with Pearson correlation to analyze Turkey's migration network structures. Hierarchical clustering uses various distance measures, including Euclidean, Chord, Mahalanobis, and others, while linkage methods group objects into clusters. The process begins by treating each data point as an individual cluster, successively merging the two closest clusters and recording the height of each merge as the distance between them. This height is then used to position the nodes vertically in the dendrogram, where the x-axis represents data points of clusters, and the y-axis shows the distance at which cluster merged. The distance matrix is updated after each merge, and the process continues until all data points form a single cluster. This visual representation provides insights into the hierarchical structure of the data and the relative similarity between clusters. However, a challenge with clustering methods lies in the need to specify cluster numbers or their sizes in advance (Murata, 2010).

Given the limitations of these techniques, studies should employ multiple methods to ensure a robust analysis, presenting one primary approach in the main results and using others for validation and robustness check.

3. METHODOLOGY

3.1. Data and Descriptive Statistics

Vietnam is geographically divided into seven regions, the Northern Mountains and Midlands, the North Delta, the North Central Coast, the South Central Coast, the Central Highlands, the Southeast, and the Southwest (Appendix A). The country utilizes two distinct classification systems- one for its provinces and another for its urban areas. A province can encompass multiple urban areas of varying classifications.

In terms of urban classification, Vietnam employs a tiered system with six levels, i.e., special-class, first-class, second-class, third-class, fourth-class, and fifth-class. The classification is based on specific criteria that account for the function, role, geographic location, and socio-economic development of each urban center. Special-class level represents the highest status, while the fifth-class level is the lowest.

Provincial, on the other hand, are classified into four ranks, special-class, first-class, second-class, and third-class. These ranks are determined by factors such as population, natural conditions, upland areas, proximity to borders, ethnic minority population, and the financial autonomy. However, this classification does not fully reflect the economic development of each province.

To address this, this study proposes an adjusted provincial classification, where the rank of a province is determined by the highest classification of each individual urban area within its boundaries. This adjustment remains consistent with the four existing ranks-special-class, first-class, second-class, and third-class-but elevates some provinces to higher ranks based on strict criteria related to function, role, geographical characteristics, and socio-economic development. As a result, Vietnam is divided into two special-class provinces, 20 first-class provinces, 18 second-class provinces, and 23 third-class provinces (Appendix B)

This study utilizes migration flow data from the Vietnam Household Living Standard Survey (VHLSS), a biennial survey conducted by the General Statistics Office (GSO). The VHLSS covers a representative sample of population at the national, regional, urban, rural, and provincial levels. From 2012 to 2018, the survey included 3,058 migrants, of which 137 were international migrants, accounting for 4.48% of the total.

Table 1. Number of Emigrants from Each Region and Its Percentage of the Total National Migration

Region	Number of total emigrants		Percentage of the total national migration	
	Within the region	*Out of the region*	*Within the region*	*Out of the region*
Northern Mountainous	169	298	5.79%	10.20%
North Delta	327	133	11.19%	4.55%
North Central	58	382	1.99%	13.08%
South Central	112	323	3.83%	11.06%
Central Highlands	52	198	1.78%	6.78%
Southeast	190	13	6.50%	0.45%
Southwest	155	511	5.31%	17.49%
Total	**1063**	**1858**	***36.39%***	***63.61%***

Data Source: VHLSS, 2012-2018

Table 1 summarizes migration statistics for seven regions in Vietnam based on VHLSS data. The findings indicate that 63.61% of emigration flows are inter-regional, while 36.39% are intra-regional. The North Delta and Southeast regions exhibit higher percentages of intra-regional emigration compared to inter-regional movement. Meanwhile, regions such as the Northern Mountainous, North Central, South Central, Central Highlands, and Southwest experienced higher rates of out-migration (inter-regional) compared to within-region migration (intra-regional). This suggests that the North Delta and Southeast regions are likely the main economic areas of Vietnam, with significant labor concentration. Within these regions, Hanoi (HN) and Ho Chi Minh (SG) have the largest populations.

At the provincial level, Ho Chi Minh (SG) and Hanoi (HN) emerged as the most popular destinations for migrants, with the immigration rates of 29.95% and 15.27%, respectively (Appendix D). On the other hand, provinces such as Dak Lak (DL, 4.19%), Ha Tinh (HT, 3.6%), Thanh Hoa (TH, 3.4%), Binh Dinh (BDd, 3.01%) and Nghe An (NA, 2.98%) recorded the highest numbers of emigrants within the sample (Appendix D).

Finally, after excluding international migrants, 2,921 observations are valid for analysis, representing internal migration flows among the 63 provinces in Vietnam. This refined dataset allows for a focused exploration of internal migration patterns, highlighting regional mobility and its implications for provincial socio-economic dynamics.

3.2. Analysis

This study adopts a two-phased approach to examine the structure of internal migration networks within Vietnam. Phase I addresses the inter-regional migration network, while Phase II focuses on the intra-regional migration network.

3.2.1. Phase I: Inter-Regional Migration Network Structure

In the first phase, the structure of the inter-regional migration network is analyzed based upon Social Network Theory (Akbari, 2021) and the multi-center approach in spatial economics (Gaspar, 2020).

Social Network Theory is used to analyze migration network because it provides a robust framework for understanding how provinces (nodes) are connected through migration flows (ties). Social Network Theory has been widely applied to study social systems and relationship between entities in various contexts, including migration, as it highlights the complex interdependencies between region (Wasserman and Faust, 1994). By using this theory, the study can identity key migration hubs and the relationships between provinces, visualizing migration as a network of connections that mirrors the structure of social ties. This allows for a better understanding of which provinces act as migration sources of destinations and how they interact within the internal migration system in Vietnam.

The multi-center approach in spatial economics explains migration patterns by focusing on the distribution of economic opportunities across various regional centers (Fujita and Thisse, 2002). It posits that migration flows are often directed towards economically dynamic regions, which act as hubs of employment, infrastructure, and resources. This approach is crucial for understanding why certain provinces attract more migrants, emphasizing how regional economic agglomeration influences migration flows (Krugman, 1991). By linking migration to economic activity, the multi-center approach offers insights into how Vietnam's regional economic disparities drive inter-regional migration.

In short, Social Network Theory views individuals and entities as nodes and their connections as ties, which parallels the hubs (centers) and economic relationships in spatial economics. The hierarchical clustering method is adopted in this study due to its suitability for exploring complex relationships in large datasets, especially when the structure of data is not predefined. Hierarchical clustering is particularly effective when the goal is to reveal nested groupings, which aligns well with the study's aim to uncover the multi-level structure of

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ISSN: 2186-8492, ISSN: 2186-8484 Print
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migration networks within Vietnam. Additionally, it provides a clear visual representation of the clustering process through dendrograms, allowing for easier interpretation of the hierarchical relationships among provinces. The method also avoids the need to pre-specify the number of clusters, which is beneficial when the optimal number of clusters is unknown or when the data may exhibit multi-level or hierarchical structures (Murtagh and Contreras, 2012). Moreover, hierarchical clustering has been widely used in social network analysis and migration studies for its ability to capture the underlying spatial dynamics of regions (Wasserman and Faust, 1994). By using Pearson correlation distance, this study ensures that the method captures both the magnitude and direction of migration flow, further justifying the choice of hierarchical clustering in this context.

A (63x63) migration matrix is constructed from the data and clustered based on Pearson correlation distance. The correlation coefficient (r_{ij}) ranges from -1 to 1, where a coefficient of zero indicates statistical independence, and a value close to ±1 reflects a perfect correlation. The migration matrix is further transformed using the following correlation distance formula to make it suitable for clustering:

$$d_{ij} = 1 - r_{ij} \quad (1)$$

This adjustment ensures that the correlation distance coefficients range from 0 to 2, with larger values indicating greater dissimilarity between regions. The cophenetic correlation coefficients (CPCCs) are then used to identify the optimal linkage method, with the highest CPCC value indicating the best fit (Murtagh and Contreras, 2012). Clustering process continues by merging regions with the smallest distances until a single cluster is formed. The results are visualized in a dendrogram, and migration clusters are labeled according to their predominant characteristics within the inter-regional migration network.

3.2.2. Phase II: Intra-Regional Migration Network Structure

The second phase examines the intra-regional migration networks within the clusters identified in Phase I. The hierarchical clustering method is employed again, but the Euclidean distance measurement is utilized instead to analyze migration flows between provinces within each migration cluster. Euclidean distance is commonly used for identifying dissimilarity when clusters are linearly separated (Sharma and Seal, 2020). It is calculated as follows:

$$d_{ij} = \sqrt{\sum_{k=1}^{n}(i_k - j_k)^2} \quad (2)$$

where n is the number of provinces in the migration cluster, i_k and j_k are the observed values for provinces i and j on variable k. In this study, the optimal linkage method is applied to visualize the similarities between provinces. The hierarchical clustering process continues by merging clusters based on the shortest distance in the matrix until all objects are combined into a single cluster. The resulting hierarchical structure is also represented in a dendrogram, which helps identifying the roles of the individual provinces within each intra-regional network.

3.2.3. Robustness Tests

To validate the findings, additional analyses are performed. K-means clustering method is replaced with the hierarchical clustering method to verify the optimal number of migration clusters within Vietnam. Community detection methods from social network analysis are also applied to compare the migration network structure results obtained from the hierarchical clustering method. All analyses are conducted using the R software, which is well-suited for clustering analysis.

4. RESULTS

4.1. Inter-regional migration network structure

Table 2 displays the CPCC values for eight primary linkage algorithms. The results indicate a good fit to the data, as evidence by P-values below 0.01 for all algorithms. The average linkage method produced the highest CPCC value of 0.9309, was identified as the optimal approach for clustering in phase I.

Figure 2 displays the cluster analysis results in a dendrogram containing 63 provinces in Vietnam, generated using the average linkage method based on the shortest distance, i.e., the lowest correlation distance coefficient in the distance matrix, or the height on the vertical axis of the dendrogram. The results suggest that categorizing the provinces into two heterogeneous clusters is optimal. Group I comprises 37 provinces, while group II consists of 26 provinces.

Table 2. CPCC Values of Linkage Algorithms for Investigating the Inter-Regional Network Structure

Linkage methods	CPCC	P-value
Average Linkage	0.9309	<0.01
Centroid Linkage	0.9214	<0.01
Complete Linkage	0.8756	<0.01
Mcquitty Linkage	0.9289	<0.01
Median Linkage	0.9097	<0.01
Single Linkage	0.6743	<0.01
Ward.D Linkage	0.8337	<0.01
Ward.D2 Linkage	0.8671	<0.01

Group I (purple) and Group II (teal) in below Figure 2 are then mapped onto the provincial map of Vietnam in Figure 3. From Figure 3, the teal-colored provinces are primarily concentrated in the northern region, with the exception of Thua Thien Hue (TTH), whereas the purple-colored provinces are located in the southern region. Accordingly, these clusters are referred to as the Northern Migration Cluster and the Southern Migration Cluster, respectively.

The Southern Migration Cluster, as shown in below Figure 3, comprises all provinces from the South Central Coast, Central Highlands, Southeast and Southwest regions, along with five provinces from the North Central Coast, Ha Tinh (HT), Nghe An (NA), Quang Binh (QB), Quang Tri (QT), and Thanh Hoa (TH). Regarding the provincial classification, this cluster consists of one special-class province, Ho Chi Minh, along with 13 first-class provinces, 12 second-class provinces, and 11 third-class provinces.

The Northern Migration Cluster encompasses all provinces from the Northern Mountainous and Midland regions, as well as those from the North Delta region, and uniquely includes TTH from the North Central Coast region, where all its other provinces are classified under the Southern Migration Cluster. This cluster consists of one special-class province, HN, along with nine first-class provinces, five second-class provinces, and 10 third-class provinces.

SG boasts an international airport, seaport, and an extensive highway and railway system, whereas HN only has an international airport, despite being centrally located within the national railway and highway systems. Regardless of lacking an international seaport, HN remains a significant cultural, political, and economic hub as the capital of Vietnam, exerting

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considerable influence over the northern cluster of Vietnam. However, the economic structure of Vietnam exhibits a distinct asymmetry, favoring the Southern Migration Cluster, with SG serving as the central hub over HN. This disparity may be explained by the fact that the Northern Migration Cluster borders the Pearl River Delta region, a major international hub in China (Lao et al., 2018), while the Southern Migration Cluster, surrounded by oceans, maintains stronger connections to global trade networks. Consequently, HN functions primarily as a domestic hub, whereas SG serves as Vietnam's main international hub. This highlights the profound influence of global economic structures on a nation's internal regional dynamics in open economies like Vietnam.

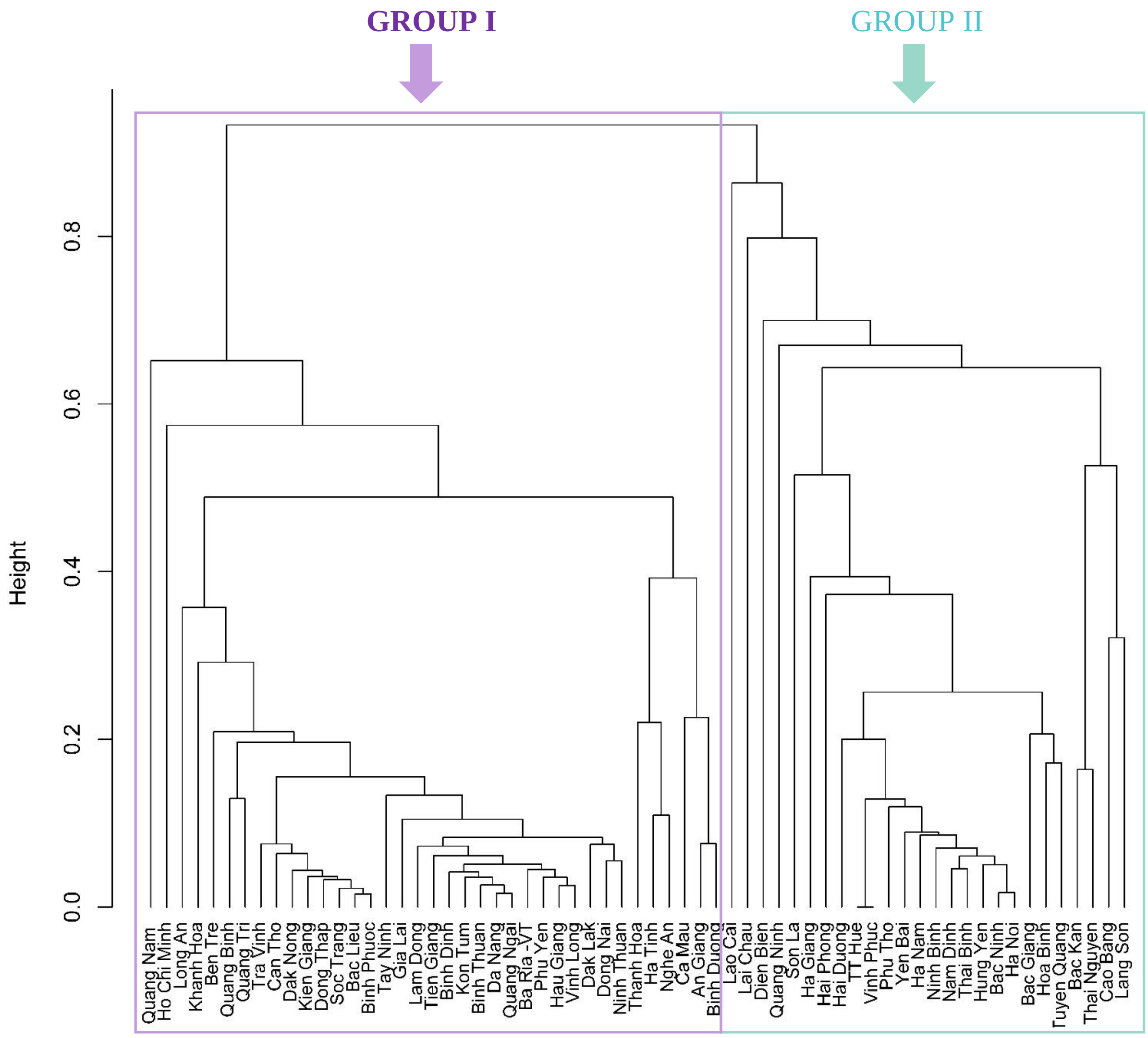

Figure 2. Cluster dendrogram with migration flows in Vietnam

4.2. Internal migration network structure

Based on the results from Phase I, Vietnam's migration matrix, originally encompassing 63 provinces (63x63), is divided into two separate data matrices representing the Northern and Southern Migration Clusters. Table 3 depicts the number and percentage of intra- and inter-cluster migrations for the study period. The Southern Migration Cluster comprises 1,833 migrants across 37 provinces, forming a (37x37) matrix, while the Northern Migration Cluster includes 868 migrants across 26 provinces, yielding a (26x26) matrix. Additionally, 111 migrants from the Southern Migration Cluster to the Northern Migration Cluster and 109 migrants in the opposite direction are excluded from this analysis. Each migration matrix is then converted into a distance matrix using Euclidean distance and subsequently subjected to hierarchical clustering analysis.

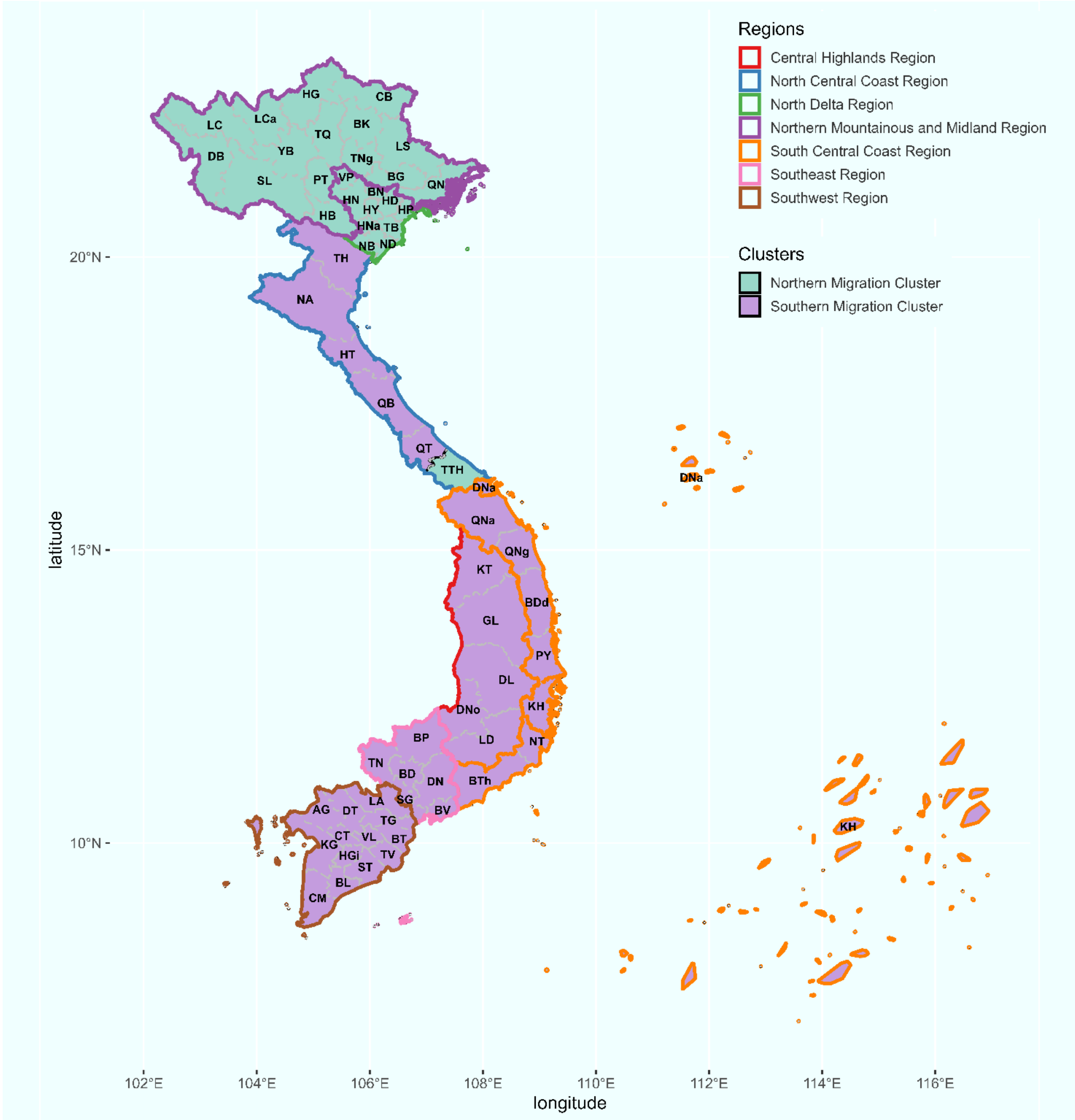

Figure 3. Mapping the two migration clusters in Vietnam

Table 3. Number and Percentage of Intra- and Inter-Cluster Migrations Relative to the Total Number of Migrants from Each Cluster and the Total National Migrations

Migration Cluster	**Number of migrants**		**Percentage of migrants within each cluster**		**Percentage of total national migrants**	
	Intra-cluster	*Inter-cluster*	*Intra-cluster*	*Inter-cluster*	*Intra-cluster*	*Inter-cluster*
Southern	1833	109	94.39%	5.61%	62.75%	3.73%
Northern	868	111	88.66%	11.34%	29.72%	3.80%
Total	2701	220			***92.47%***	***7.53%***

Sources: Author's Calculation

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ISSN: 2186-8492, ISSN: 2186-8484 Print
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Table 4 presents the results of the hierarchical clustering analysis applied to examine the internal structures of the Southern and Northern migration clusters individually. The highest CPCC values were obtained using the average linkage algorithm, with 0.9969 and 0.9978 for the Southern and Northern clusters, respectively. The consistently significant p-values across all linkage algorithms, all below 0.01, led the study to adopt the average linkage method to investigate intra-migration within these two clusters.

Table 4. CPCC Values of Linkage Algorithms for Investigating the Structure of the Clusters

Linkage algorithms	Southern migration cluster		Northern migration cluster	
	CPCC	P-value	CPCC	P-value
Average Linkage	0.9969	<0.01	0.9978	<0.01
Single Linkage	0.9968	<0.01	0.9968	<0.01
Complete Linkage	0.9961	<0.01	0.9962	<0.01
Mcquitty Linkage	0.9964	<0.01	0.9972	<0.01
Centroid Linkage	0.9962	<0.01	0.9976	<0.01
Ward.D Linkage	0.9962	<0.01	0.9824	<0.01
Ward.D2 Linkage	0.8874	<0.01	0.9945	<0.01
Median Linkage	0.9950	<0.01	0.9977	<0.01

Figure 4 displays the dendrograms of the Southern and Northern Migration Clusters separately. The dendrogram in Figure 4(a) reveals that the Southern Migration Cluster is divided into two groups: the central region centered around SG and its surrounding provinces. Adjacent to SG, BD ranks second in terms of the number of immigrants within the Southern Migration Cluster, and is also classified as a first-class province.

For the Southern Migration Cluster as shown in Figure 4(a), *Đồng Nai* (DN) and DNa, positioned within the same branch, exhibit similar immigration patterns and are both classified as first-class provinces. However, the sources of migrants to DNa differ significantly from those of major immigration hubs such as SG, BD, and DN. Specifically, DNa attracts migrants primarily from the North Central Coast and Central Highlands regions, acting as a crucial socio-economic and political center between these two regions. Nevertheless, migration to DNa remains lower compared to SG, BD, and DN, which are all located in the Southeast region (Appendix D). If DNa can strengthen its industrial and economic infrastructure to compete with these provinces, it could emerge as a key hub for migration within its neighboring regions and form an independent cluster distinct within the Southern Migration Cluster.

Regarding the Northern Migration Cluster, as depicted in Figure 4(b), it exhibits a similar structure to its counterpart, the Southern Migration Cluster. Two major groups are identified, HN as the core area, with surrounding provinces forming peripheral zones. Among the peripheral provinces, BN stands out due to its higher immigrant numbers. The remaining provinces are divided into three branches. The most prominent branch includes provinces such as QN, TNg, Hai Phong (HP), Hung Yen (HY), TTH, and Vinh Phuc (VP), which exhibit higher migration levels compared to the other groups and are classified as first-class provinces (Appendix D). The remaining branches mainly contain provinces located farther from the core area.

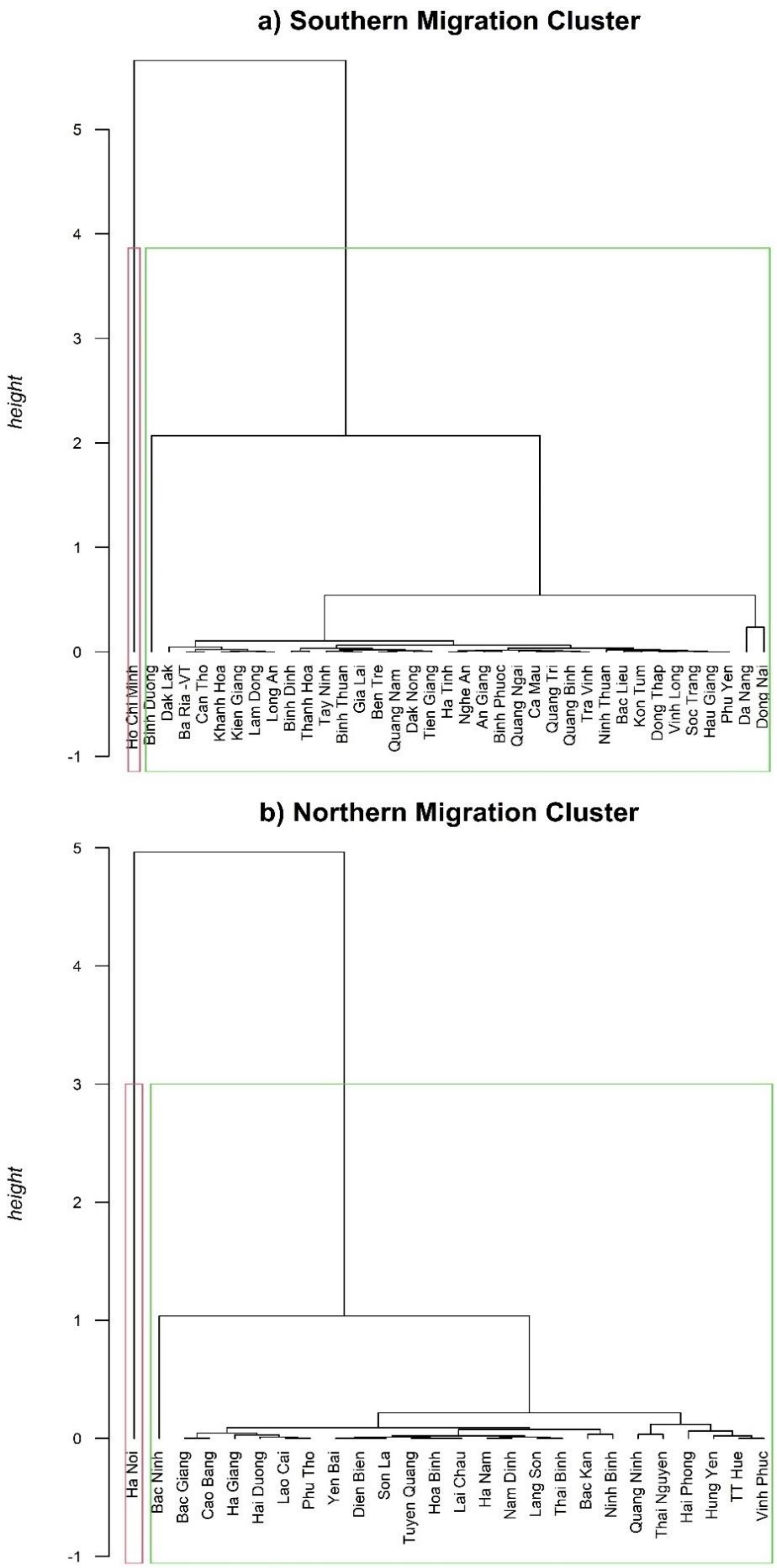


Figure 4. Cluster dendrogram of immigrants in each cluster

BD and BN provinces have emerged as the second-largest immigration centers within the Southern and Northern migration clusters, respectively, and display distinctly from other provinces in their respective clusters. Their proximity to the primary immigration centers within their own clusters designates them as sub-cores. Intriguingly, both sub-core regions are located to northeast of the primary cores, aligning with major international shipping routes in the Pacific Ocean and key economic centers across East Asia. This spatial arrangement contributes to an asymmetrical internal structure observed within both migration clusters.

Moreover, there is a strong correlation between the hierarchical rank of provinces within each dendrogram branch and their respective provincial classifications. Special-class provinces, such as SG and HN, hold the highest hierarchical degrees, followed by first-class provinces such as BD and BN. The third-ranking branches, represented in in both dendrograms shown in Figure 4, comprising other first-class provinces such as DNa and DN, QN, TNg, HP, and TTH, with the exception of HY and VP (see Appendix B). For the remaining provinces, as the branches descended within the dendrograms, their provincial classification diminishes, indicating a megalopolitan internal structure within both migration clusters.

The clear distinction between the Northern and Southern Migration Clusters displays distinct migration dynamics across Vietnam. Provinces within the same cluster share similar migration patterns. For example, the southern cluster suggests a closer connection between the southern and central provinces such as SG and QNa, potentially due to economic opportunities or historical ties. In contrast, the northern cluster displays greater internal variation, which may be attributable to differences in economic development, urbanization, or regional migration policies.

In summary, the results reveal the presence of an asymmetrical, megalopolitan intra-regional migration network structure within Vietnam (Figure 5).

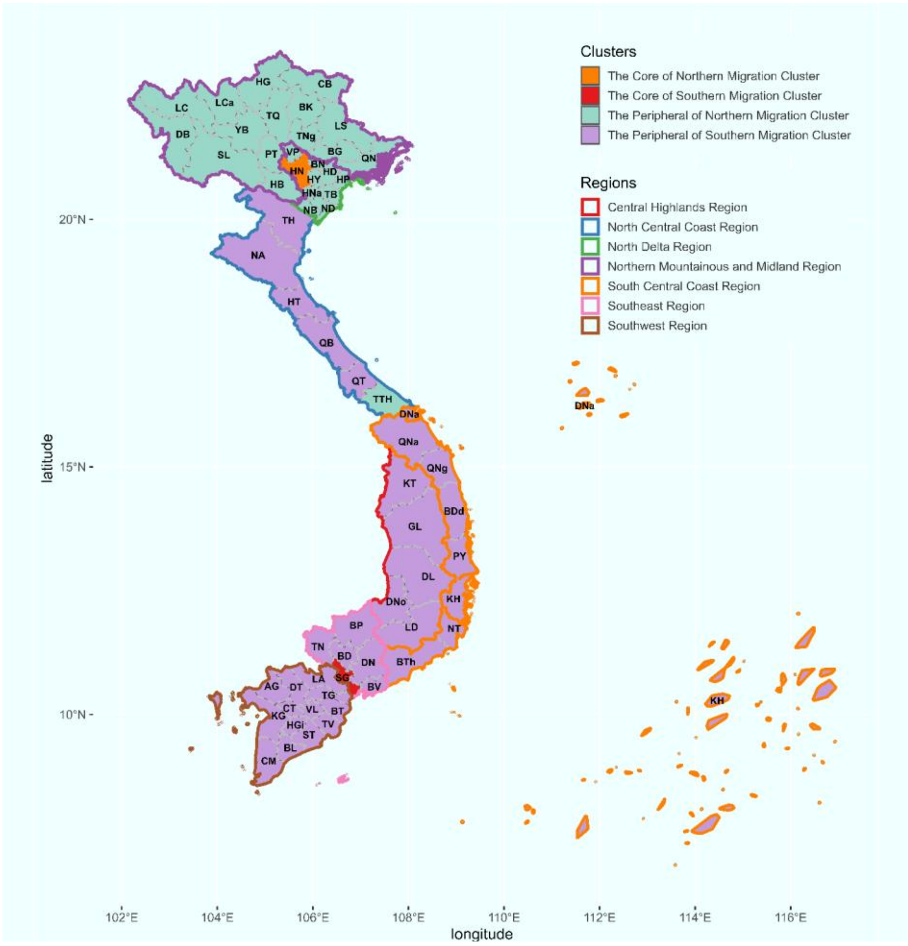


Figure 5. Clustering and mapping of the regions based on internal migration flows

4.3. Comparison between Inter- and Intra-Cluster Migration Network Structures

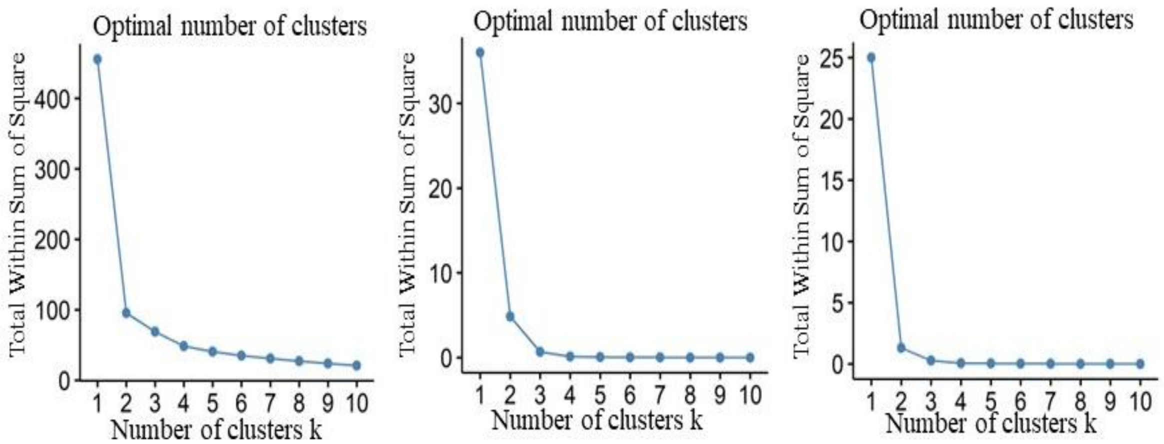
According to Table 3, in the Southern Migration Cluster, the percentage of intra-cluster migration is 94.39%, while inter-cluster migration is 5.61%. In the Northern Migration Cluster, the rates are 88.66% and 11.34%, for intra-cluster and inter-cluster migration respectively.

These results confirm the preference for intra-regional migration over inter-regional migration, a trend highlighted in social network theory. The Southern Migration Cluster shows a high proportion of intra-regional migration (62.75% of the total national migrants) compared to the Northern Migration Cluster (29.72%) nationwide. This underscores the asymmetric racetrack spatial distribution of Vietnam's economic agglomeration, contributing significantly to the growth of the southern migration cluster.

4.4. Robustness test

4.4.1. The optimal cluster numbers in the K-means clustering methods

The K-means clustering analysis is employed to determine the optimal number of migration clusters across three network structures, i.e., the Southern Migration Cluster, the Northern Migration Cluster, and their inter-regional network. As illustrated in Figure 6, the results suggest that these each structure should be partitioned into two clusters, based on the elbow method criteria. The distinct change at k = 2 forms a characteristic “elbow” shape, indicating the optimal number of clusters. This result is consistent with the findings from the hierarchical clustering analysis presneted above.



a) Inter-regional migration clusters *b) Southern migration cluster* *c) Northern migration cluster*

Figure 6. The robust test: the optimal number with the elbow method in the K-means clustering method

4.3.2. Community detection based on edge betweenness

Community detection is conducted using the social network analysis to examine the migration network structures in Vietnam. Figure 7 presents the results, illustrating two major regions represented by cyan and light pink, along with their respective cores. DB and LC emerge as isolated regions due to geographical and socioeconomic constraints, such as rugged mountain terrain, inadequate infrastructure, and social disparities among ethnic minorities. The cyan area encompasses all provinces in the Northern Mountainous and Midlands regions, as well as the Northern Delta region, with the exception of TTH in the North Central Coast region.

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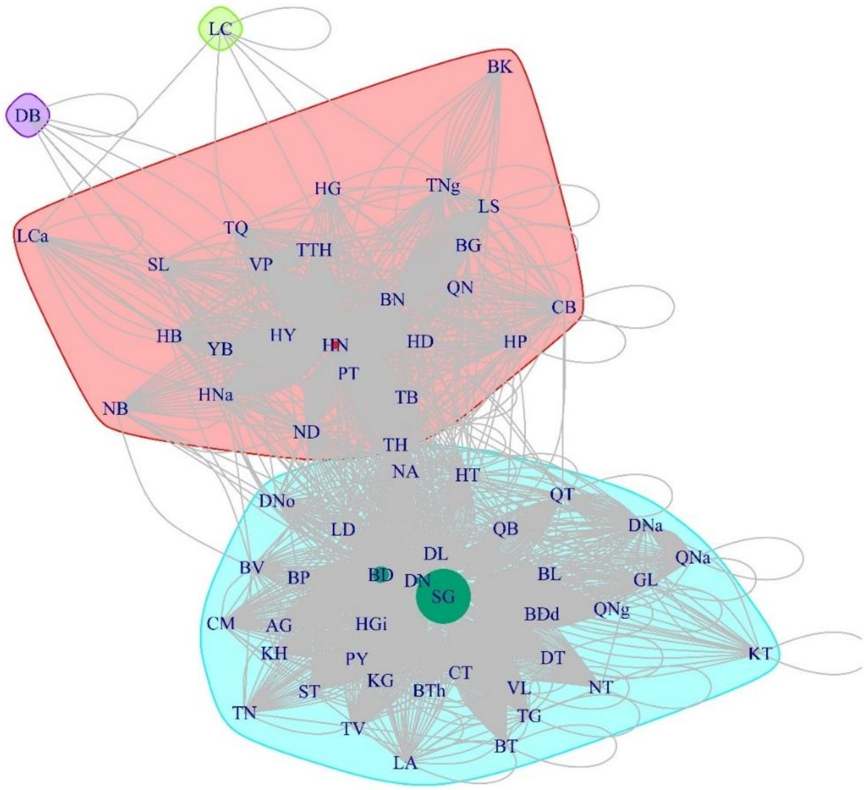

Figure 7. The robust test: the result of community detection based on edge betweenness for the migration flows structure

Two core regions are clearly identified: HN, marked in red, and SG, highlighted in green. Additionally, several other nodes, such as BD, DN, DNa, BDd, BN, and CT, appear significantly smaller in Figure 7. The remaining 53 provinces are barely identifiable by their node colors alone and require adjacent text labels for clear identification. However, this limitation does not impact the findings of the study, as these provinces are located on the periphery of the two primary regions, represented by cyan and light pink. This noticeable variation in node size among provinces reflects their peripheral positions within the network structure, rather than integration into the core areas. These social network analysis results are consistent with those obtained from the hierarchical clustering method, confirming the presence of two internal regional networks, each with a clear distinction between core and peripheral areas.

5. CONCLUSİONS AND DİSCUSSİON

The present study unveils a fundamental distinction between inter-regional and intra-regional network structures in Vietnam concerning migration flows. Vietnam's migration network comprises two major regional networks, the Southern and the Northern Migration Cluster. Each is characterized by cores and peripheral areas, with more pronounced development in the southern cluster. The intra-regional structure of these two networks reflects megalopolitan patterns, albeit asymmetrically oriented towards the east, connecting international shipping routes and major economic centers in East Asia. This study therefore significantly contributes to the fields of social network analysis and spatial economics.

5.1. Implications for Spatial Economics

The findings of this study provide additional evidence for theoretical models of agglomeration economies concerning the number of economic regions within a country.

Specifically, the results indicate that Vietnam, between 2012 and 2018, exhibited two asymmetrical economic regions, a pattern also observed in Turkey (Akın and Dökmeci, 2015). These results offer empirical support for the agglomeration economy models proposed by Castro et al. (2012) and (Ikeda et al., 2018), which focus on even numbered regional structures. Nevertheless, the study also highlights Vietnam's potential to develop a third economic region centered around Da Nang (DNa). While this possibility may appear to diverge from the models of Castro et al. (2012) and (Ikeda et al., 2018), it is consistent with theories of economic network formation influenced by geographical borders or international trade policies (Gaspar et al., 2021). Drawing on evidence from countries with an odd number of economic regions-such as Croatia and Austria, each with one (Pitoski et al., 2021a; Pitoski et al., 2021b), and China with three (Lao et al., 2018)-this study suggests that the evolution of agglomeration economies within a country may be shaped more significantly by spatial agglomeration alone.

On the other hand, the intra-regional network structures exhibit megalopolitan agglomeration patterns, aimed at optimizing inputs by reducing iceberg transportation costs and capitalizing on economies of scale (Biagi et al., 2018). Gaspar et al. (2021) confirmed the pivotal roles of transportation costs and economies of scale in shaping regional network structures within a country. In certain cases, a racetrack agglomeration model may emerge when transportation costs outweigh the benefits of economies of scale, whereas megalopolitan agglomeration patterns may form under the conditions of lower transportation costs (Gaspar et al., 2021). Transportation costs between regions are significantly influenced by geographical characteristics such as terrain and distance. To mitigate regional disparities within the intra-regional structure, a racetrack agglomeration model- with evenly distribution intra-regional transportation infrastructure proportional to the size of economic center-would be preferable.

5.2. Implications for Urban Management

This study offers practical implications for urban management in Vietnam. The results reveal that the country’s inter-regional migration network structure is divided into two clusters. The Northern Migration Cluster centered around HN; and the Southern Migration Cluster, centered around SG, along with their respective peripheral areas. In addition, understanding the intra-regional network structures can provide valuable insights for formulating urban management strategies, particularly in relation to Vietnam's value-added economic network. For instance, integrating provinces in the Northern Mountainous Midland region with Hanoi could facilitate the exchange of goods and resources in the market, as well as labor mobility. This approach could also help address regional inequalities by creating more direct links between peripheral areas and economic hubs, thereby increasing access to employment and services for rural populations.

Furthermore, the study suggests the potential emergence of a new cluster within the Southern Migration Cluster, centered around DNa, if Vietnam continues to experience substantial economic growth and improvements in transportation infrastructure post-2018. This cluster could encompass peripheral provinces like QNa, forming a new economic and migration hub in the South-Central Coast region. However, this scenario faces challenges due to the evolving global dynamics of, particularly in light of geopolitical shifts following the Ukraine conflict, which have profound implications for the global economic structure (Liu and Shu, 2023). These changes could influence Vietnam's economic landscape and the potential formation of new migration clusters in unforeseen ways.

The development of transportation infrastructure, including air, rail, and sea systems, should prioritize connectivity within the inter-regional network structure. The megalopolitan nature of the intra-regional network suggests the need for a comprehensive highway system

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surrounding core areas (Zhang, 2020). Effective transportation development can generate positive externalities, such as improved air quality, environmental preservation, equitable access, social justice, and enhanced disaster resilience (Zhang, 2020). Consequently, national budget allocations for provincial transportation infrastructure should be based on the demand for upgrading both the inter-regional and intra-regional network structures, rather than solely adhering to the notion of equality.

5.3. Contributions to Social Network Theory

This study contributes to social network theory by emphasizing the dynamic nature of migration flows within countries, influenced by the socio-economic connections between regions (Gaspar et al., 2021). For instance, migration from TTH in the Northern migration cluster reflects social connection in migration flows, while megalopolis network structures highlight the importance of economies of scale in two main migration clusters. Furthermore, this study identifies a tendency for intra-regional migration over inter-regional migration, which may be attributed to lower socio-economic costs (Akbari, 2021; Windzio et al., 2021). This trend is further supported by the significantly lower rate of international migration in Vietnam compared to domestic migration, highlighting the high social costs associated with international migration.

5.4. Limitations and Future Research

A key limitation of this study is the static nature of the data, which only covers the period from 2012 to 2018. This constraint is particularly notable given the rapid development of Vietnam's road infrastructure after 2018, especially between 2021 and 2024, when the number of new highways nearly doubled compared to previous years. As a result, the analysis may not fully reflect recent shifts in migration trends or emerging economic factors tied to this infrastructure expansion. Additionally, unobserved variables-such as informal networks, local policies, or cultural factors-that may influence migration decisions are not accounted for in the study. Future research should utilize more recent and dynamic datasets, and consider additional qualitative factors to ensure the robustness and generalizability of the findings.

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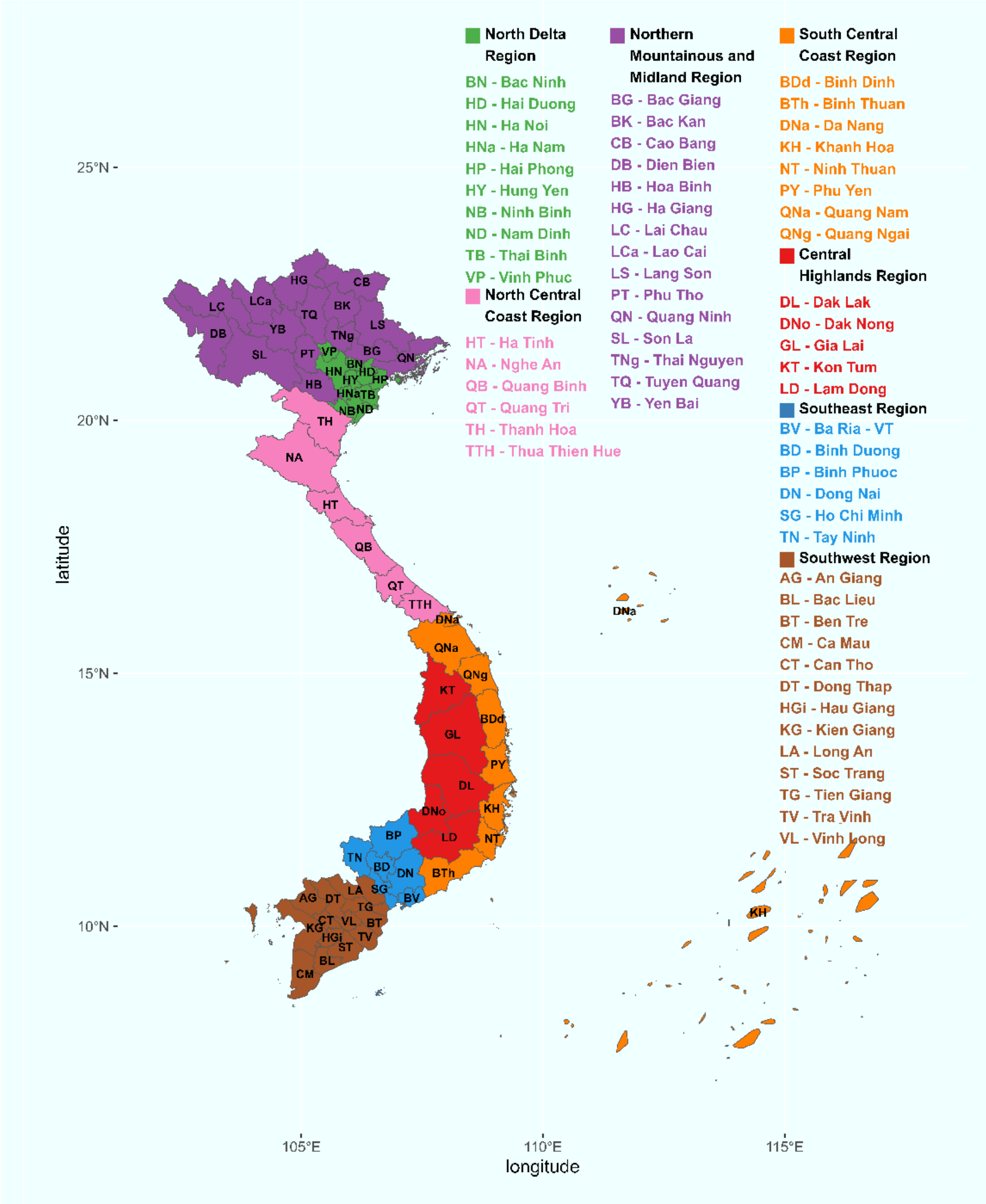
APPENDICES

Appendix A: The regional and provincial map in Vietnam



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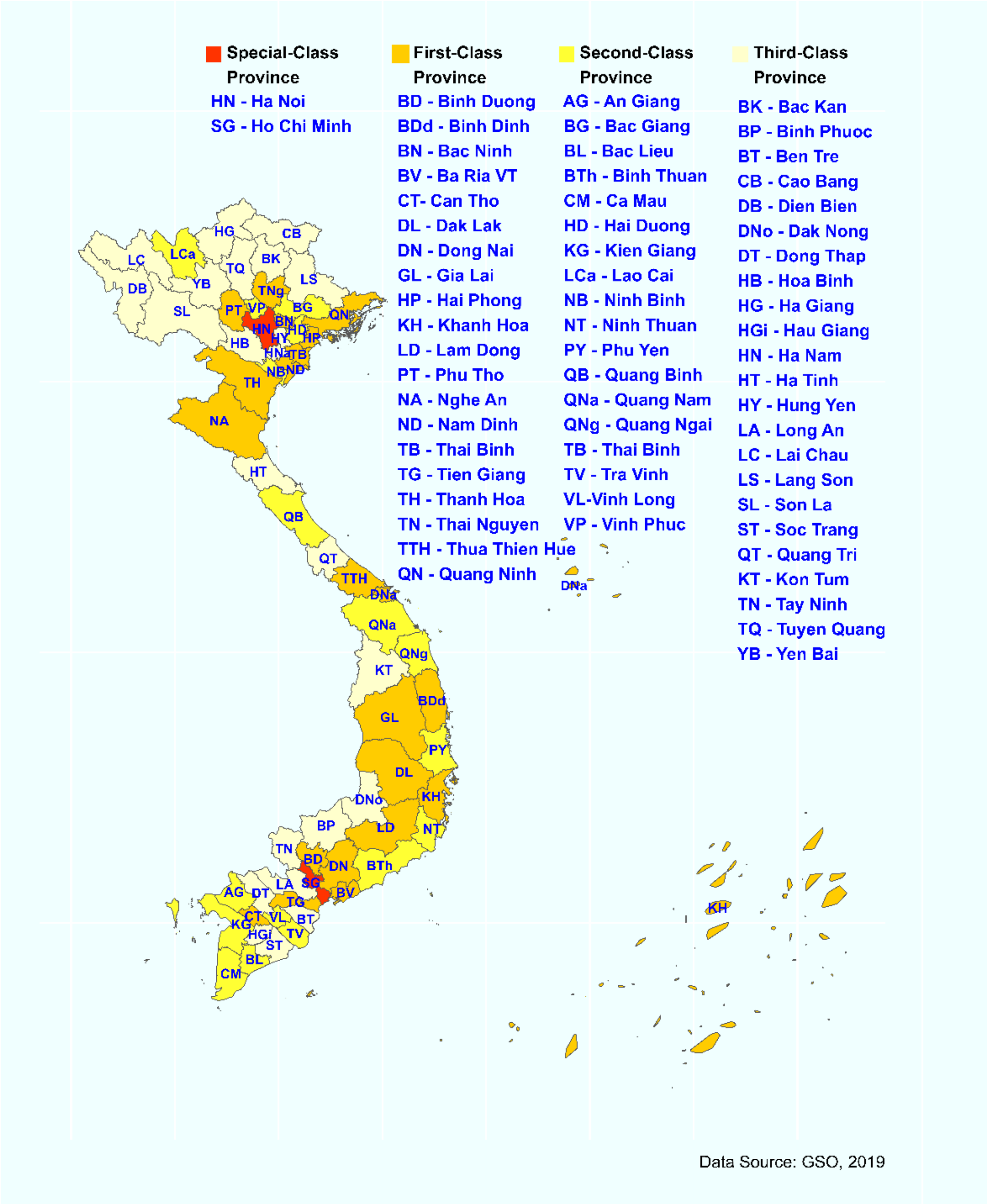
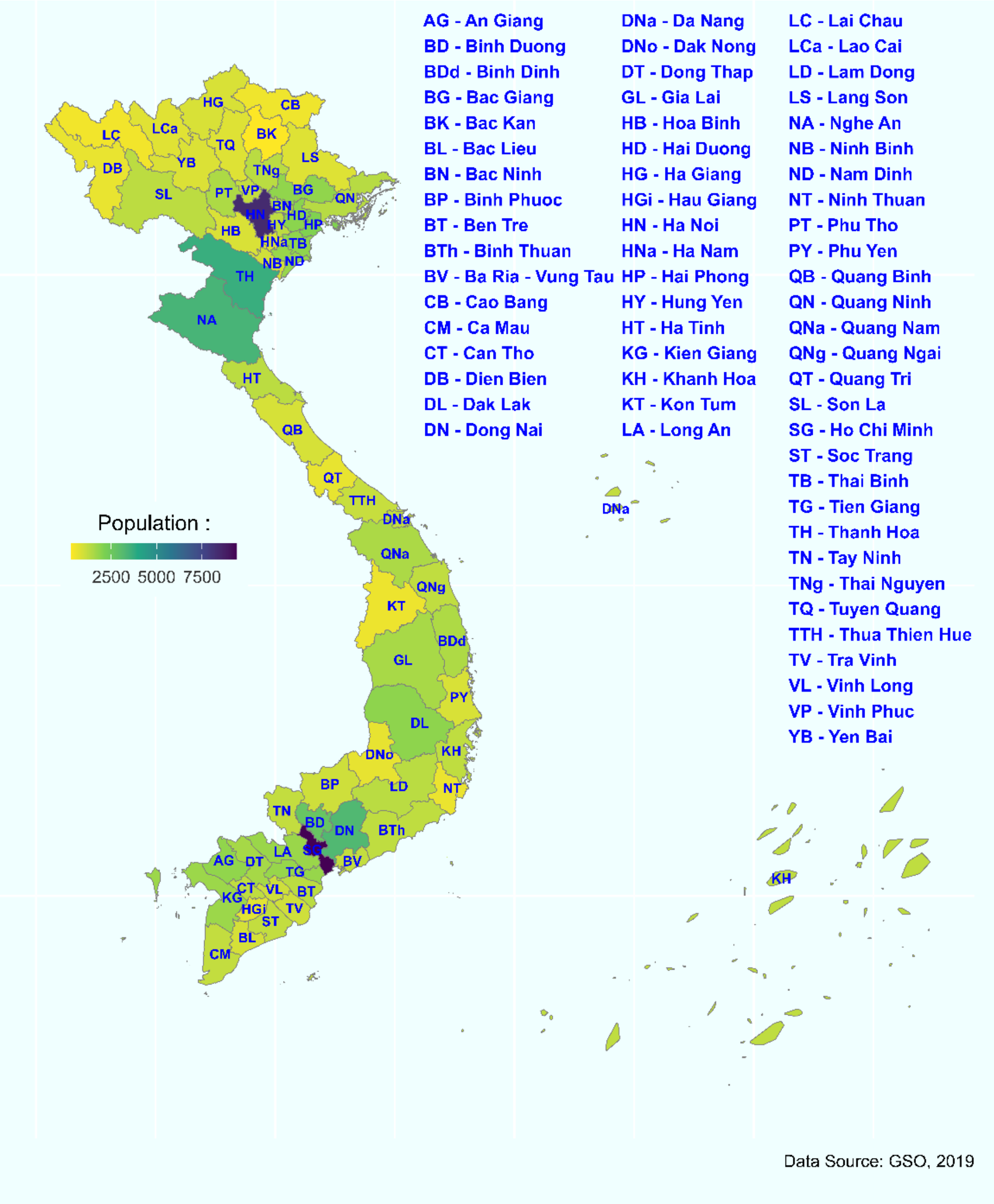
Appendix B: Ranks by Provinces for Vietnam



Appendix C: Population (in thousands) by Provinces for Vietnam



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Appendix D: **Percentage of immigration and emigration by provinces relative to the total national migrations**

No	Province	Abbreviation	Immigration (%)	Emigration (%)	Migration Cluster
	Northern Mountainous and Upland		***7.69***	***16.06***	
1	Bac Giang	BG	0.65	1.18	Northern
2	Bac Kan	BK	0.07	0.39	Northern
3	Cao Bang	CB	0.65	1.34	Northern
4	Dien Bien	DB	0.33	0.52	Northern
5	Ha Giang	HG	0.46	0.78	Northern
6	Hoa Binh	HB	0.29	1.18	Northern
7	Lai Chau	LC	0.29	0.26	Northern
8	Lang Son	LS	0.36	1.44	Northern
9	Lao Cai	LCa	0.56	0.29	Northern
10	Phu Tho	PT	0.56	2.68	Northern
11	Quang Ninh	QN	1.31	0.82	Northern
12	Son La	SL	0.33	0.69	Northern
13	Thai Nguyen	TNg	1.21	1.28	Northern
14	Tuyen Quang	TQ	0.29	1.18	Northern
15	Yen Bai	TB	0.33	2.03	Northern
	North Delta		***23.44***	***16.21***	
16	Bac Ninh	BN	3.6	0.95	Northern
17	Ha Nam	HNa	0.39	1.47	Northern
18	Ha Noi	HN	15.27	1.54	Northern
19	Hai Duong	HD	0.52	1.83	Northern
20	Hai Phong	HP	1.05	0.85	Northern
21	Hung Yen	HY	0.82	2.09	Northern
22	Nam Dinh	ND	0.39	2.84	Northern
23	Ninh Binh	NB	0.16	0.78	Northern
24	Thai Binh	TB	0.36	2.19	Northern
25	Vinh Phuc	VP	0.88	1.67	Northern
	North Central Coast		***2.91***	***16.23***	
26	Ha Tinh	HT	0.36	3.6	Southern
27	Nghe An	NA	0.36	2.98	Southern
28	Quang Binh	QB	0.33	2.52	Southern
29	Quang Tri	QT	0.29	2.06	Southern
30	Thanh Hoa	TH	0.69	3.4	Southern
31	TT Hue	TTH	0.88	1.67	Northern
	South Central Coast		***5.73***	***14.29***	
32	Binh Dinh	BDd	0.72	3.01	Southern
33	Binh Thuan	BT	0.49	2.03	Southern
34	Da Nang	DN	2.65	0.46	Southern

35	Khanh Hoa	KH	0.82	1.57	Southern
36	Ninh Thuan	NT	0.07	1.34	Southern
37	Phu Yen	PY	0.16	2.06	Southern
38	Quang Nam	QNa	0.56	2.22	Southern
39	Quang Ngai	QNg	0.26	1.6	Southern
Central Highlands			***3.24***	***8.28***	
40	Dak Lak	DL	1.11	4.19	Southern
41	Dak Nong	DNo	0.59	0.72	Southern
42	Gia Lai	GL	0.49	1.08	Southern
43	Kon Tum	KT	0.2	0.49	Southern
44	Lam Dong	LD	0.85	1.8	Southern
Southeast			***46.9***	***6.91***	
45	Ba Ria -VT	BV	0.95	0.69	Southern
46	Binh Duong	BD	11.25	0.56	Southern
47	Binh Phuoc	BP	0.43	1.44	Southern
48	Dong Nai	DN	3.86	2.55	Southern
49	Ho Chi Minh	SG	29.95	0.59	Southern
50	Tay Ninh	TN	0.46	1.08	Southern
Southwest			***5.62***	***22.04***	
51	An Giang	AG	0.39	2.16	Southern
52	Bac Lieu	BL	0.23	1.11	Southern
53	Ben Tre	BT	0.56	1.57	Southern
54	Ca Mau	CM	0.29	1.77	Southern
55	Can Tho	CT	0.95	1.6	Southern
56	Dong Thap	DT	0.13	1.83	Southern
57	Hau Giang	HG	0.16	2.84	Southern
58	Kien Giang	KG	0.82	1.9	Southern
59	Long An	LA	0.85	1.01	Southern
60	Soc Trang	ST	0.16	1.54	Southern
61	Tien Giang	TG	0.62	1.8	Southern
62	Tra Vinh	TV	0.33	1.44	Southern
63	Vinh Long	VL	0.13	1.47	Southern
Abroad			***4.48***		
Total			***100***	***100***	

Data Source: VHLSS, 2012-2018

Leena and Luna International, Chikusei, Japan.
(株) リナアンドルナインターナショナル, 筑西市,日本
ISSN: 2186-8492, ISSN: 2186-8484 Print
www.ajssh.leena-luna.co.jp