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Special Issue

Analyzing the Influences of Economic Opportunity and Residential Substitutability on Population Migration by Age Group*

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Abstract

Population imbalance in South Korea is intensifying owing to an increasing concentration in metropolitan areas and a progressive decline of peripheral regions. A nuanced understanding of life cycle dynamics is necessary for an effective policy response to depopulation. Migration is driven by the complex interactions of socioeconomic factors, whose relative influence varies across different stages of the life cycle. This study employs a life cycle approach to analyze the determinants of migration, focusing on regional socioeconomic characteristics and the roles of economic opportunity and residential substitutability. We employ a spatial econometric model that incorporates spatial interactions between economic opportunity and residential substitutability into the spatial weight matrix. Bayesian posterior probability is used to identify the interregional migration determinants. The results show that economic opportunity is the primary driver of migration among young adults (ages 20–29). Furthermore, the findings indicate that simultaneously considering both economic opportunity and residential substitutability across different areas enhances the attractiveness of specific areas for migration, particularly for the stages of family formation (ages 30–39) and child-education (ages 40–49). These findings offer empirical insights for designing sustainable responses to local depopulation and support the implementation of regional balanced development policies.

Keywords Population Migration, Economic Opportunity, Residential Substitutability, Spatial Econometric Model

Ⅰ. Introduction

South Korea is currently facing a severe demographic imbalance, characterized by population concentration in metropolitan areas and large cities, alongside the depopulation of rural areas. The “rural exodus”, referring to the population migration from small and medium-sized cities to metropolitan areas, has contributed to regional disparities, even during times of overall population growth. The recent trend of nationwide population stagnation, coupled with unprecedentedly low birth rates and an aging population, has accelerated the deterioration of small and medium-sized cities in rural areas (Jeong and Hong, 2019; Koo, 2021). Individuals' tendency to relocate to more attractive regions in pursuit of better living conditions and economic opportunities has intensified interregional competition to attract residents. Regions experiencing population decline often fall into a vicious cycle, where reduced regional attractiveness leads to further out-migration (Nam and Seo, 2018).

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In local labor markets, regions with abundant local assets and advanced technology are more likely to attract highly skilled workers. Consequently, human capital accumulates in more attractive regions, thereby further exacerbating regional disparities (Fratesi and Riggi, 2007; Fratesi and Percoco, 2014).

Migration is a cumulative process associated with various life events such as education, employment, marriage, and childbirth throughout an individual's life cycle (Bernard et al., 2014). It is driven by a complex set of socioeconomic factors (Castelli, 2018) and serves as a vital means for individuals to achieve their goals and aspirations, enhancing their economic and social well-being (Bernard and Bell, 2018; de Haas, 2021). Motivations for and determinants of migration vary across different stages of the life cycle. Studies analyzing migration across life cycle stages have found that major transitions, such as entering university, beginning a career, and becoming independent from one's parents, are most likely to occur in early adulthood. This results in frequent migration during this period (Rindfuss, 1991; Bernard et al., 2014; Lee and Choi, 2023). Key transitions such as marriage, childbirth, and career changes also drive migration. Migration patterns are strongly connected to the individual life cycle; regions with similar life cycle characteristics often exhibit comparable migration trends throughout the life cycle stages (Bernard et al., 2014). Therefore, in order to minimize regional imbalances and develop effective regional policies, it is crucial to understand the mechanisms of individual migration decisions from a life-cycle perspective. Specifically, it is necessary to analyze how migration determinants change over life cycle stages and vary depending on regional characteristics (Bonifazi et al., 2021).

Studies on the determinants of migration have primarily focused on economic factors, such as income, employment, and wages, as well as regional characteristics, such as housing conditions, educational facilities, and climate. However, these studies have not adequately considered how these factors vary throughout the life cycle (Kim and Yang, 2013; Etzo, 2011; Piras, 2017). Researchers have used the gravity model to explain migration systems in terms of socioeconomic differences between regions. However, there has been little consensus on the interactions among these factors (de Haas, 2021). Although economic opportunity is an important driver of migration, it is not the only factor that influences migration decisions. Migrants choose destinations based on financial constraints, considering economic opportunities as well as factors such as commuting convenience, housing conditions, and social networks (Rincke, 2010). In reality, migration is the result of a complex interplay of socioeconomic factors that determine its direction and characteristics (Castelli, 2018). Therefore, it is vital to understand economic opportunities, the balance between jobs and housing, and the interactions among various factors when examining the determinants of migration and formulating policies to address regional population imbalances. A comprehensive analysis of the spatial relationships between regions that influence migration, along with an assessment of how changes in these relationships affect migration dynamics, is essential.

This study examines migration as a phenomenon driven not only by regional socioeconomic differences but also by multiple spatial relationships and complex interactions that serve as key mechanisms of migration throughout the life cycle. Using a spatial econometric approach, we consider residential substitutability, economic opportunities, and spatial dependence while accounting for the possibility of asymmetric migration across regions. Specifically, we apply a spatial autoregressive (SAR) panel model (LeSage and Pace, 2008) to analyze the simultaneous effects of spatial relationships on determinants of migration by age group. In light of population decline and out-migration trends in rural areas, understanding spatial relationships and their complex effects is paramount. The final model incorporates spatial effects through various spatial weight matrices. Bayesian posterior probabilities of different models are then compared to identify the most appropriate analysis framework. This approach effectively explains complex interregional migration patterns across the life cycle and provides a valuable methodology for analyzing both single and multiple spatial effects (Kim et al., 2025).

Ⅱ. Literature Review

1. The Gravitational Influences of Interregional Migration

Theoretical discussions on migration decisions provide an academic foundation for understanding interregional migration. Demographic studies traditionally explain the causes of population movement using push and pull factors, based on the push-pull theory proposed by Lee's (1966) push-pull theory (Park and Kim, 2020; Laajimi and Gallo, 2022). According to this theory, migration occurs through the interplay of individual and regional characteristics, alongside pushing factors that drive people to leave their current residence and pulling factors that attract them to new areas (Lee, 2009). The theory provides a comprehensive framework for analyzing how regional socioeconomic conditions in both origin and destination areas, combined with individual characteristics, influence migration decisions at the individual and regional levels.

The gravity model is a traditional framework used to explain macro-level population movement based on the distance and differences in characteristics between two areas. In Ravenstein's (1885) first gravity model, the main factors influencing population mobility were population size and distance between two locations. Subsequently, Lowry (1966) emphasized the role of economic factors as major determinants of population migration. He created a modified version of the conventional gravity model that incorporated regional economic disparities. Lowry (1966) specifically examined how the economic circumstances in two areas affect workers' migration decisions, proposing that people typically migrate from areas with higher unemployment and lower wages to areas with lower unemployment and higher wages.

The push-pull theory and the gravity model are representative frameworks for explaining population migration at macro level. Both models emphasize the significant impact of the socioeconomic characteristics of the origin and destination areas on individuals' migration decisions. The gravity model which accounts for migration based on differences in characteristics between two areas and can be extended by incorporating the in- and out-migration factors proposed in the push-pull theory (Ramos, 2016). In this extended gravity model, the push and pull factors influencing individual migration decisions are conceptualized as gravitational forces, represented by socioeconomic variables reflecting each area's relative attractiveness (Karemera et al., 2000; Poot et al., 2016).

A destination's attractiveness to migrants is influenced by the area's various socioeconomic factors. Economic opportunities, educational environments, and housing conditions, in particular, are critical determinants when migrants choose a new area. Traditional economic variables, such as regional average wages, income levels, GRDP (gross regional domestic product) per capita, and employment rates, indicate the economic opportunities available in a destination and significantly affect population inflow (Etzo, 2011; Piras, 2017). High-income areas, which offer abundant economic opportunities, act as a pull factor for migrants. Conversely, individuals from areas with lower economic levels may choose to migrate in search of better opportunities (Cavalleri et al., 2021). Based on this theoretical framework, the present study posits that disparities in regional economic levels are a primary driver of migration and examines how spatial disparities in economic opportunities contribute to interregional migration.

2. Characteristics of Interregional Migration across Life Cycle

According to the push-pull theory, propelling and attraction factors are perceived differently based on migrants' individual characteristics and circumstances. This suggests that the same regional conditions may lead to different migration outcomes (Lee, 2008). This provides an empirical basis for considering migration characteristics by life cycle in addition to regional-level characteristics, when studying interregional migration (Lee, 2009; Park and Kim, 2020).

From a life-cycle perspective, migration is a cumulative process shaped by an individual's life-cycle stages and social needs. Common patterns are observed among individuals with similar life-cycle trajectories (Bernard et al., 2014; Cavalleri et al., 2021; Lee and Choi, 2023). In South Korea, for example, migration activity peaks during the 20s, which corresponds with the transition into higher education and employment. This activity then gradually declines as individuals approach retirement age (Lee and Kim, 2020). During the young adult period (ages 20-29), migration is driven primarily by the pursuit of occupational success and personal growth opportunities (Hong and Yoo, 2012; Rindfuss, 1991). During the family formation period (ages 30-39), residential choices are largely influenced by child-rearing and family stability considerations. Migration decisions at this stage are shaped by a combination of factors, including opportunities for career advancement, educational quality, and housing conditions (Mulder and Hooimeijer, 1999; Choi et al., 2010). Similarly, during the child-education period (ages 40-49), migration patterns reflect a focus on improving the educational environment for children. Migration during this stage involves strategic decisions aimed at enhancing the overall quality of life for the family while balancing job stability and educational needs (Hong and Yoo, 2012). During the middle-aged period (ages 50-64), migration tends to align with preparations for life after retirement. Key motivations for migration at this stage include career transitions, homeownership, and retirement planning (Choi et al., 2010). Other important factors influencing migration decisions during this period also include housing quality, lower living costs, and access to community welfare services (de Jong, 2022).

A comprehensive and systematic analysis of migration throughout the life cycle is imperative because the primary drivers of migration vary significantly at each stage. Migration is a complex and dynamic phenomenon that cannot be fully explained by economic factors or regional characteristics alone. This study aims to gain a more accurate understanding by comprehensively analyzing the evolving needs and drivers of migration across the different stages of an individual's life cycle.

3. Spatial Interaction and Interregional Migration

The gravity model is a traditional framework for explaining population migration. It focuses on the relationship between the areas of origin and destination. It provides a simplified method for modeling the intricate mechanisms that underlie migration (Poot et al., 2016). Several studies on interregional migration have used the gravity model, considering socioeconomic disparities and physical distances between regions as the main factors influencing migration (Etzo, 2011; Wajdi et al., 2017; Cavalleri et al., 2021; Yoon, 2015; Lee and Won, 2017). However, the gravity model has a significant limitation: it only considers the relative differences between the origin and destination areas, ignoring the potential influence of other areas. In reality, migration decisions are not solely determined by the relative differences between two specific areas. They are also influenced by the relative differences and similarities of other potential destinations. Consequently, failing to account for the spatial relationships among alternative areas can lead to biased estimates of migration determinants (Bertoli and Moraga, 2013).

To overcome the limitations of the gravity model and more clearly illustrate spatial relationships among different regions, some migration studies have adopted spatial econometric models that presume spatial dependence between neighboring regions (LeSage and Pace, 2008; Pu et al., 2019). These studies examine the impact of spatial dependence on interregional migration by constructing spatial weight matrices that capture endogenous interactions with neighboring areas. However, interregional migration is influenced not only by spatial interactions based on physical distance and proximity, but also by the socioeconomic relationships between areas. Indicators of physical proximity do not adequately capture these factors. Several studies have addressed this limitation by using spatial weight matrices that incorporate socioeconomic relationships, such as technological proximity (Parent and LeSage, 2008), economic proximity (Boarnet, 1998), and residential substitutability (Rincke, 2010). Furthermore, it is difficult to assume that spatial relationships between regions are symmetrical (Parent and LeSage, 2008). Instead, asymmetrical socioeconomic relationships observed in real-world contexts should be incorporated into the analysis. Consequently, efforts have been made to incorporate asymmetric interactions into spatial weight matrices. For instance, gravitational influence has been applied (Bu et al., 2022; Kim et al., 2025), and hierarchical relationships between areas have been reflected (Jeong, 2024). These asymmetric interactions more accurately capture the complexity of spatial relationships among regions and enable more reliable estimates for explaining the intricate mechanisms underlying interregional migration (Elhorst and Halleck Vega, 2017).

This study examines the gravitational influence of in- and out-migration intensities (which reflect the asymmetry of economic opportunities) and regional substitutability (which reflects the substitutability of residence) on interregional migration. Specifically, we consider the asymmetric nature of spatial interactions when modeling migration patterns to identify how these factors influence migration dynamics.

Ⅲ. Methodology

1. Scope of Study

This study analyzes the factors that influence migration across the different stages of the life cycle. It focuses particularly on how residential substitutability and economic opportunity affect migration decisions. The analysis covers 226 administrative units (si, gun, and gu) in South Korea, excluding island regions, over the period from 2011 to 2020. Notably, this period captures a range of pivotal policy shifts and demographic inflection points, including the implementation and spatial diffusion of the Innovation Cities policy, deregulation in metropolitan development, and the early intensification of youth concentration in the capital region. These developments reflect the onset of irreversible structural transformations, such as persistent regional depopulation and the reconfiguration of life-stage-specific migration dynamics.

To reflect spatial interactions, we construct spatial weight matrices that exclude island or geographically isolated regions, since commuting via land routes is not feasible. This exclusion is a deliberate design consideration that ensures spatial contiguity–based models do not systematically marginalize certain regions and that the spatial interaction structure reflects actual regional connectivity. Using spatial econometric models and spatial weight matrices, this study empirically analyzes spatial migration patterns while incorporating interregional interactions. ⟨Table 1⟩ provides a summary of the variables used in this study.

2. Data Implementation

1) Outcome Variables

To analyze the drivers of interregional migration throughout the life cycle, we use both in- and out-migration intensities. Migration intensity is calculated by dividing the number of migrants by the population of each region. This results in two separate measures: in-migration intensity and out-migration intensity. Rather than representing the absolute number of migrants, this indicator reflects the proportion of migrants relative to the local population, thereby adjusting for regional population size. This relative measure of mobility is useful in demographic research, as it enables meaningful comparisons of migration activity across regions of different sizes (Bell et al., 2015; Bonifazi et al., 2021; Kim et al., 2025; Kulu et al., 2018).

Migration has long been linked to the level of socioeconomic development (Bell et al., 2015). In this context, the intensity of regional migration inflows and outflows is influenced by the interplay of local socioeconomic push-and-pull factors (Bertoli and Moraga, 2013). South Korea, in particular, experiences a high level of migration intensity compared to other countries (Bell et al., 2015). This is driven by population concentration and suburbanization in the metropolitan area, alongside overall population stagnation and decline. Although general population growth trends and migration intensity explain regional migration patterns and population changes, migration intensity can also vary according to population age structure (Kulu et al., 2018). Several studies have examined migration intensity by age-specific subgroups (Hunt, 2004; Finnie, 2004) and have sought to identify the drivers of interregional migration based on age-related characteristics. Across age groups, various migration drivers—such as education, employment, moving to affluent areas, marriage and childbirth, and preparing for later life—can occur simultaneously, with some factors playing a more prominent role than others (Hong and Yoo, 2012). To enhance the comprehensibility of these dynamics, this study provides a distinct analysis of migration by age group. Accordingly, it divides the life cycle into four stages: the young adult period (ages 20-29), the family formation period (ages 30-39), the child-education period (ages 40-49), and the middle-age period (ages 50-64). The analysis excluded individuals who were 65 years or older because migration reasons tend to be highly varied and migration intensity tends to be lower for this age group (Longino et al., 2008). The formula used to calculate the migration intensity is as follows: In equation (1), IMI_t^x and OMI_t^x represent the in- and out-migration intensities at time t, respectively, and P_x represents the population of the specified age group x.

$$IMI_t^x = \frac{IM_t^x}{P_t^x} \times 100; OMI_t^x = \frac{OMI_t^x}{P_t^x} \times 100 \qquad (1)$$

⟨Figures 1 and 2⟩ illustrate that the intensity of both in- and out-migration is highest among the young adults (ages

Table 1. Outcome and predictor variables

Variables	Calculation	Mean	Std. Err	Unit	Data source
Outcome variables					
Total in-migration intensity	(Total in-migrants/Total population) × 100	9.61	3.89	%	KOSIS
Total out-migration intensity	(Total out-migrants/Total population) × 100	9.62	3.41	%	
Young adult in-migration intensity	(Young adult in-migrants/Ages 20-29 population) × 100	16.26	4.65	%	
Young adult out-migration intensity	(Young adult out-migrants/Ages 20-29 population) × 100	18.28	4.60	%	
Family formation in-migration intensity	(Family formation in-migrants/Ages 30-39 population) × 100	14.71	4.09	%	
Family formation out-migration intensity	(Family formation out-migrants/Ages 30-39 population) × 100	15.30	4.10	%	
Child-education in-migration intensity	(Child-education in-migrants/Ages 40-49 population) × 100	8.79	2.92	%	
Child-education out-migration intensity	(Child-education out-migrants/Ages 40-49 population) × 100	8.43	2.40	%	
Middle-aged in-migration intensity	(Middle-aged in-migrants/Ages 50-64 population) × 100	6.85	2.17	%	
Middle-aged out-migration intensity	(Middle-aged out-migrants/Ages 50-64 population) × 100	6.16	1.87	%	
Predictor variables					
Population density	Total (residential) population/Local area	3.97	6.22	1,000 people/km^2	KOSIS
GRDPPC	Real GRDP/Total (residential) population	34.32	32.40	million won/people	KOSIS
Creative-class ratio	Employment in creative-class/Total employment	23.87	7.06	%	KOSIS
Educational attainment	Average years of schooling of the population	11.35	1.39	years	KOSIS
Average land price	∑(Land price of each parcel × each parcel area)/ Total parcel area	0.59	1.08	million won/m^2	MOLIT
Local development budget ratio	Development budget/Total local budget	8.44	5.13	%	MOIS
Secondary industry change	Annual percentage changes in employment in secondary industry	5.15	11.98	%	KOSIS
Tertiary industry change	Annual percentage changes in employment in tertiary industry	3.64	4.50	%	KOSIS

※ KOSIS, Korean Statistical Information Service; MOLIT, Ministry of Land, Infrastructure and Transport; MOIS, Ministry of the Interior and Safety

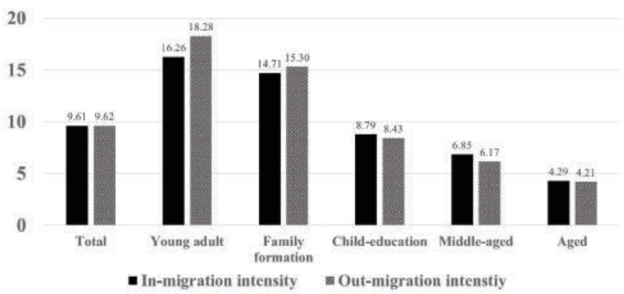

Figure 1. In- and out-migration intensity by life cycle

20-29) and generally declines with age. Notably, beginning with the child-education age group (ages 40-49), the intensity of in-migration begins to exceed that of out-migration. This shift reflects changing motivations for migration throughout the life cycle. During young adulthood and family formation (ages 20-39), migration is often driven by higher education, employment opportunities, independence, and marriage. This results in elevated mobility toward metropolitan areas, such as Seoul, and other urban

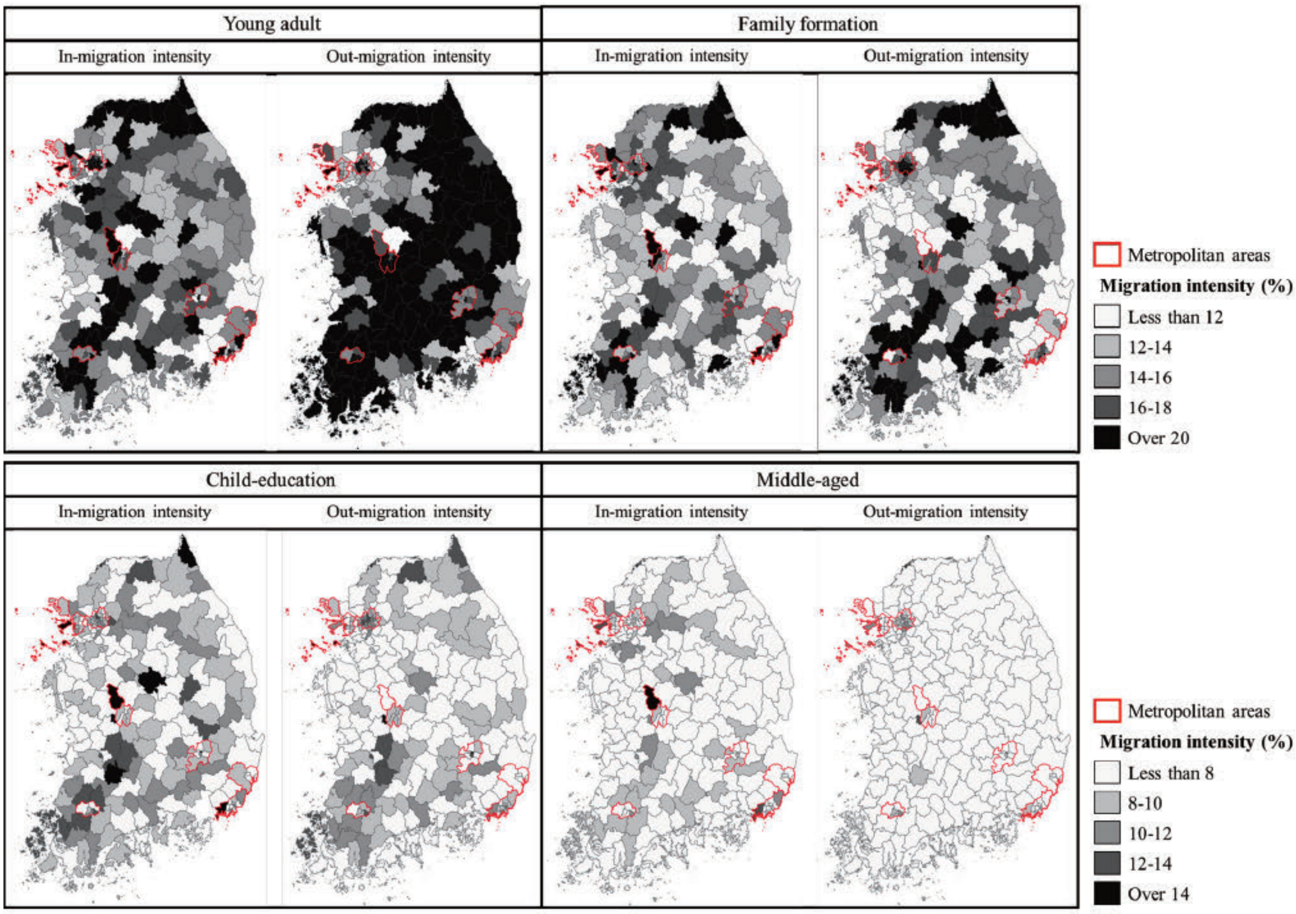

Figure 2. Migration intensity of South Korea (average of 2011-2020)

centers that offer abundant educational and employment opportunities. In contrast, older age groups, particularly those in the child-education and middle-aged stages, tend to migrate for settlement purposes, influenced by considerations such as children's education, housing stability, and quality of life. In-migration to suburban areas or mid-sized cities, especially in the periurban areas, reflects a selective migration pattern associated with family reestablishment or retirement preparation.

2) Predictor Variables

Several socioeconomic factors that are strongly correlated with interregional migration were selected as predictor variables. In addition to the traditional gravity model (Tinbergen, 1962), many studies have identified factors such as population size and density as major drivers of migration (Karemera et al., 2000; Piras, 2017). GRDP per capita (GRDPPC) was particularly adopted as a key factor influencing interregional migration because it reflects regional economic growth, economic opportunities, and the status of the local labor market (Etzo, 2011; Piras, 2017). Regions with higher levels of economic development tend to have larger labor markets and more attractive amenities, increasing their appeal to migrants seeking higher wages or greater labor productivity during the job search process (Higa et al., 2019). To account for price fluctuations, GRDP was adjusted for inflation using 2015 as the base year. The creative class ratio, reflecting the relative size of local human capital, is also an important factor in migration patterns. Migration intensity is often more closely associated with the employment of local creative classes because people and companies tend to relocate to regions with a higher concentration of skilled workers (Florida, 2002). In this study, the creative class includes sectors such as broadcasting and media, science and technology services, education, healthcare, and arts and sports (Florida et al., 2008). Additionally, we included human capital variables, such as the average years of education in a region, which were included in the analysis (Piras, 2017; Winters, 2011; Shen and Wang, 2012). We examined land prices as variables reflecting a region's economic value, including accessibility and environmental characteristics, and adopted the average land price as a key variable to capture regional preferences broadly (Glumac et al., 2019; Hong and Yoo, 2012). Differences in local amenities significantly impact migration decisions, as households tend to relocate based on economic considerations (Higa et al., 2019). The marginal willingness to pay for amenities can be inferred from implicit prices, such as those expressed in land or housing prices (Bayer et al., 2009). Local development budgets, which are allocated for purposes such as new city development, housing supply, and regional regeneration, are considered factors that influence population growth (Jeong and Gim, 2023). Changes in regional employment and industrial structure are critical aspects of regional development. An increase in the number of workers in a specific industry indicates growth in that sector (Shi and Wang, 2024). We used the rate of change in the secondary and tertiary industries to identify shifts in the regional industrial structure.

3) Residential Substitutability

Residential substitutability refers to the extent to which a specific region is considered an interchangeable alternative to other regions when households choose where to live in the housing market (Rincke, 2010). Grounded in interregional similarity, such as residential environment attractiveness and workplace connectivity, this concept can be estimated empirically using commuting patterns. Essentially, when individuals decide where to live and work, regions with similar commuting patterns can be considered as mutually substitutable from the residents' perspective. Regions with similar substitution potential, or comparable commuting patterns, can be regarded as highly substitutable by households in either region. Regions with similar commuting patterns among households are more likely to be perceived as highly substitutable residential locations. McDuff (2011) demonstrated that this substitutability significantly influences migration decisions and is powerful predictor of residential mobility.

This study empirically estimates residential substitutability by using annual interregional commuting data from the Korea Transport Database (KTDB). Specifically, equation (2) presents a substitutability index based on commuting flows, in the line with Rincke's (2010) approach. Specifically, c_{ij} denotes the number of individuals who reside in region i and commute to region j. The substitutability index s_{ij} measures the distinctiveness of commuting from region i to region j relative to commuting flows from i to all other regions. The index ranges from 0 to 1. A value closer to 1 indicates that the region is a dominant commuting destination for residents of the region i. A value closer to 0 suggests that commuting from region i is more evenly distributed across multiple destinations. To improve interpretability, the index was transformed $s^*_{ij} = 1 - s_{ij}$, so that values closer to 1 indicate greater similarity between regions. Through this approach, the study quantitatively assesses the strength of residential substitutability between regions based on commuting behavior.

$$s_{ij} = \frac{1}{2} \sum_{k \neq i,j} \left| \frac{c_{ik}}{\sum_{m \neq i,j} c_{im}} - \frac{c_{jk}}{\sum_{m \neq i,j} c_{jm}} \right| \qquad (2)$$
$$s^*_{ij} = 1 - s_{ij}$$

4) Economic Opportunity

Most studies on spatial interactions between areas assume that the interactions between two areas are symmetric. While this assumption simplifies the model estimation process, in reality, there is the possibility that interactions between areas are asymmetric (Parent and LeSage, 2008). This asymmetry limits the ability to fully explain potential spatial dependence (Zhu et al., 2022). For example, the spillover effect from region A to region B may differ from the spillover effect from region B to region A, a difference that the symmetry assumption fails to account for. Assuming migration is driven by the economic disparity between areas, there may be asymmetric migration flows from region A to region B compared to those from region B to region A, due to differences in economic activity levels. This asymmetric spillover effect aligns with the theoretical and empirical findings indicating that areas with higher economic levels tend to attract more population due to the gravitational effect (Etzo, 2011; Piras, 2017; Cavalleri et al., 2021). Migration is a dynamic process influenced by housing and labor markets. In order to comprehend the factors that either facilitate or impede migration, it is necessary to take into account both economic opportunities and mobility costs (Haas and Osland, 2014).

This study aims to capture the gravitational influence of economic opportunities on interregional migration by accounting for differences in relative economic levels and accessibility between regions. Specifically, equation (3) constructs a gravitational index, e_{ij}, that combines the ratio of GRDPPC between two regions with the inverse of the minimum travel time, T_{ij}. This reflects spatial variation in economic opportunities and identifies asymmetries in migration flows (Bu et al., 2022; Haas and Osland, 2014; Parent and LeSage, 2008). Minimum travel time includes both road and rail transport and is inverted to account for spatial friction. Notably, the GRDPPC ratio undergoes a square root transformation to reduce the skewness caused by economically dominant regions, and to ensure a more balanced interaction between economic potential and accessibility. This non-linear transformation is consistent with conventional gravity models, where it has been widely applied to enhance the empirical and theoretical realism for variable relationships (Osborne, 2002; Parent and LeSage, 2008).

$$e_{ij} = \left(\frac{GRDPPC_j}{GRDPPC_i}\right)^{1/2} \times \frac{1}{T_{ij}} \tag{3}$$

3. Model Construction

This study models the impact of interregional interactions on migration by incorporating these interactions into a spatial weight matrix. First, the spatial econometric model considers the spatial spillover effects on neighboring regions by applying a spatial weight matrix based on regional adjacency. Next, the spatial weight matrix is extended to include economic opportunities and residential substitutability. Finally, we integrate predictor variables into the fixed effects of the panel model to account for unobserved regional heterogeneity.

1) Spatial Econometric Model

Most studies attempt to explain the dynamic changes in migration patterns over a specific period. To address the challenges of population stagnation, depopulation, and concentration in metropolitan areas, it is crucial to examine the drivers of migration across various life cycle stages. Thus, this study analyzes a 10-year period (2011-2020) to derive general results.

Spatial econometric models are useful for controlling for spatial interactions in continuous space (Kim et al., 2025) and enable the evaluation of economic opportunities and residential substitutability between areas. This research's primary objective is to empirically analyze and present the differential effects of economic opportunities and residential substitutability on migration in an intuitive manner, using the SAR panel model (LeSage and Pace, 2008) in an intuitive manner. Fixed effects models are generally considered more appropriate than random effects models when using spatio-temporal data at the regional level (Elhorst, 2014), a finding that is further confirmed by the statistical verification in this study. Consequently, this analysis employs SAR panel model with two-way fixed effects.

$$Y_{i,t} = \rho \sum_{j=1}^{N} W_{ij} Y_{j,t} + X_{i,t}\beta + \nu_i + \psi_t + \epsilon_{i,t} \tag{4}$$

In the above equation (4), the outcome variable vector $Y_{i,t}$ is $N \times 1$ dimensional and represents the in-migration and out-migration intensity for each region at time t. $X_{i,t}$ contains the predictor variables and constant term vectors and is $N \times K$ dimensional, and β is $K \times 1$ dimensional parameter of the regression. W_{ij} is the element i, j of the spatial weight matrix that reflects the spatial interaction of the N regions that comprise the regional panel. All spatial weight matrices were standardized to have row sums equal to unity. The parameter ν_i is a fixed effect for the region and ψ_t is a fixed effect for time. $\sum_{j=1}^{N} W_{ij} Y_{j,t}$ reflects the endogenous interaction between the outcome variable of region i and the outcome variables of all other regions j, and ρ is a parameter associated with it.

2) Model Construction Using Spatial Weight Matrix

The spatial weight matrix captures migration intensity based on the relationships between adjacent regions and the influence of economic opportunities and residential substitutability. 〈Table 2〉 outlines the process for constructing the spatial weight matrix. In the context of multilateral migration, the intensity of migration between two areas is influenced not only by the relative attractiveness of the destination area but also by the attractiveness of other potential destinations (Bertoli and Moraga, 2013; LeSage and Pace, 2008). Consequently, the spatial weight matrix b_{ij} was

Table 2. Development of different models

Model	Definition	Model construction with spatial weight matrix
Model 0	A model that does not consider spatial dependencies between local areas	Spatial weight matrix is not used.
Model 1	A model that assumes even spatial dependence between adjacent local areas	Contiguity weight matrix: $b_{ij} = 1$ if i and j are contiguous, otherwise $b_{ij} = 0$; (with $b_{ij} = 0$ if $i = j$)
Model 2	A model that assumes both spatial dependence between adjacent local areas and residential substitutability	Residential substitutability weight matrix: $w^{s}_{ij} = b_{ij} \circ (1 - s^{*}_{ij})$; (with $w^{s}_{ij} = 0$ if $i = j$)
Model 3	A model that assumes both spatial dependence between adjacent local areas and economic opportunity	Economic opportunity weight matrix: $w^{e}_{ij} = b_{ij} \circ e_{ij}$ (with $w^{e}_{ij} = 0$ if $i = j$)
Model 4	A model that assumes influences of both economic opportunity and residential substitutability between local areas	Economic opportunity and residential substitutability weight matrix: $w^{se}_{ij} = w^{s}_{ij} \circ w^{e}_{ij}$; (with $w^{se}_{ij} = 0$ if $i = j$)

constructed using an adjacency-based method to account for the impact of neighboring areas. To incorporate the effect of residential substitutability, the adjacency-based weight matrix was multiplied by the Hadamard product(∘) of the residential substitutability between regions. Spatial influence can be uniquely defined by applying the Hadamard product to both spatial relationships and socioeconomic factors (Dubé and Legros, 2013). This approach enables the spatial weight matrix (w^{s}_{ij}) to capture both residential substitutability and the spatial relationships between areas simultaneously. Similarly, economic opportunity was incorporated into the contiguity-based weight matrix (w^{e}_{ij}), with economic gravity weights applied when selecting migration destinations (Bu et al., 2022; Parent and LeSage, 2008). Finally, recognizing that migration decisions are influenced by multiple factors simultaneously (Kim et al., 2025), the two matrices were combined to reflect the simultaneity, resulting in the final spatial weight matrix w^{se}_{ij}.

All models were estimated using the SAR panel model with the Quasi Maximum Likelihood Estimation (QMLE) method (Yu et al., 2008). The analysis was conducted using the 'SDPDmod' package in R version 4.2.1. The variance inflation factors (VIFs) for all models were below 5, indicating that multicollinearity was not a concern. This was not examined further in the models. All models also supported the appropriateness of the two-way panel structure ($p<0.001$). Additionally, the Hausman test confirmed that the fixed-effects model was more suitable than the random-effects model ($p<0.01$).

3) Model Comparison

Instead of clarifying the relationship between outcome variables and predictor variables, this study aims to compare the fit of different models and identify the model that best reflects the impact of economic opportunity and residential substitutability within a migration system. To address the uncertainty inherent in spatial panel models, a Bayesian posterior probability approach is recommended for comparing spatial weight matrices (LeSage, 2014; Rios et al., 2017). Traditional model comparison methods, such as Lagrange multiplier statistics, likelihood ratio tests, and Wald statistics, focus on specific parameter estimates. In contrast, the Bayesian approach evaluates the entire parameter space when comparing models (Firmino Costa da Silva et al., 2017). Additionally, using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) to compare models can result in biased estimates when the same predictors are utilized (Hollenbach and Montgomery, 2020), which complicates the identification of integrative relationships using spatial weighting matrices (Mur and Angulo, 2009). Since this study involves constructing multiple non-nested models with the same predictors, the Bayesian posterior probability approach is introduced for comparing spatial weighting matrices (LeSage, 2014). We identify the spatial weighting matrix that most effectively explains the interregional migration system by comparing models using posterior probabilities (Firmino Costa da Silva et al., 2017). The Bayesian posterior probability serves as a consistent predictor within the spatial econometric model, with all parameters evaluated according to the log-marginal likelihood function.

Ⅳ. Result

1. Spatial Statistical Findings of Migration Intensity by Age Group

We present key spatial statistical findings on the intensity and spatial patterns of interregional migration across the life cycle stages in South Korea. Our results reveal how migration motivations and spatial dependencies differ by age group and region, providing valuable insights into population migration dynamics.

To explore the spatial dynamics of interregional migration by age group, we conducted a spatial statistical analysis focusing on the spatial clustering of migration intensity and spatial dependence. 〈Figure 3〉 shows the results of spatial statistical analysis. It reveals that Seoul has a high concentration of in-migration among young adults. In contrast, non-metropolitan regions in the southeast and southwest have a high concentration of out-migration among the same age group. However, Seoul shows a relatively high concentration of out-migration intensity, except among the

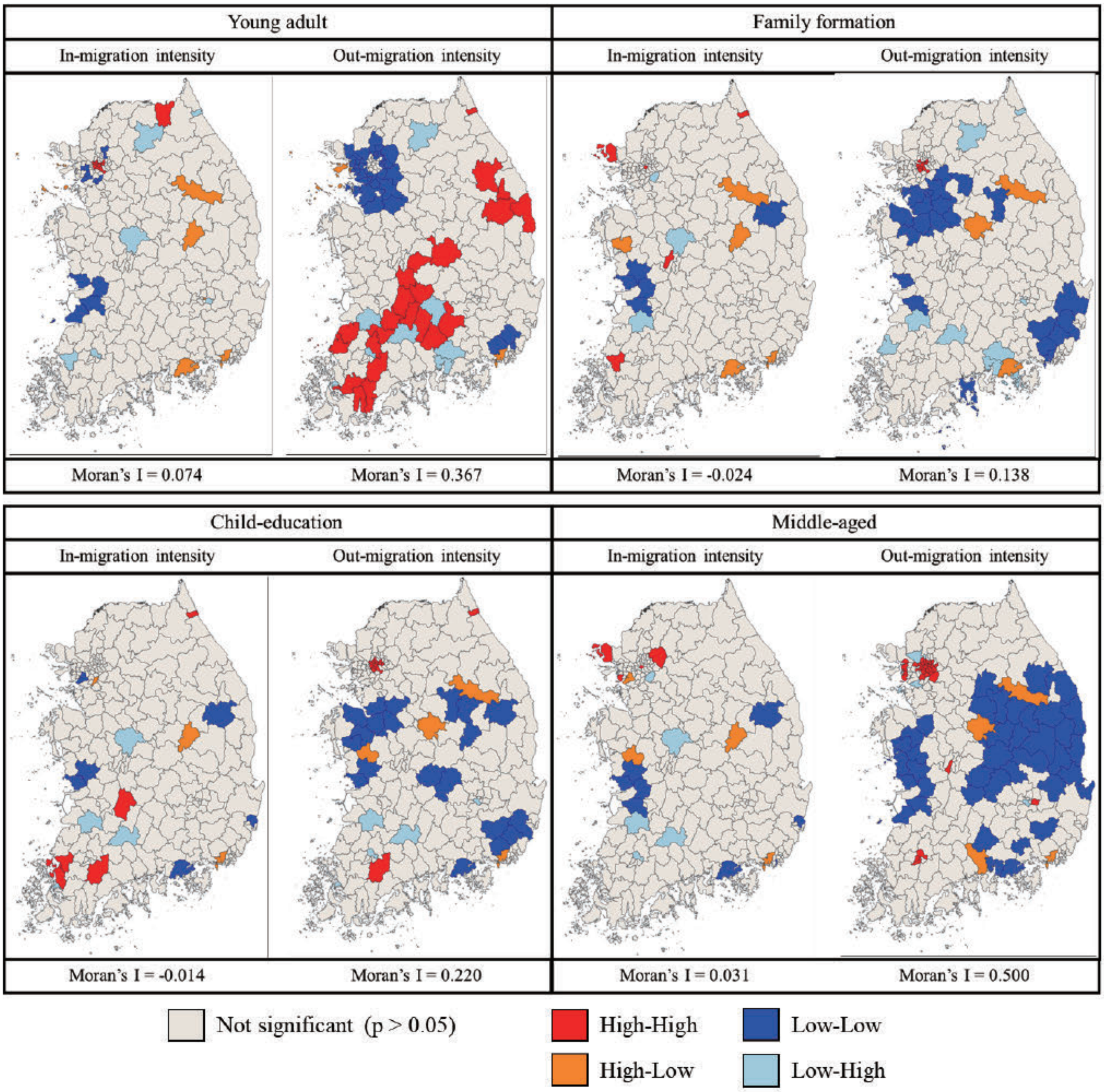

Figure 3. Spatial statistics of migration intensity of South Korea (average of 2011-2020)

young adults, suggesting that individuals are gradually moving away from central urban areas as they enter the latter stages of life. For the family formation, child-education, and middle-aged groups, the spatial clustering of in-migration intensity is either weak or statistically insignificant, indicating a more dispersed pattern of annual average migration intensity. When assessing overall spatial clustering over time using panel data and yearly global Moran's I statistics on the residuals of the regression model, however, most years exhibit significant positive spatial dependence ($p<0.05$). This suggests that migration intensity is generally not randomly distributed but spatially structured, despite the relatively weak clustering observed in specific age groups. This reinforces the importance of incorporating spatial dependence into the modeling framework to more accurately reflect interregional migration dynamics.

Overall, the findings emphasize that migration intensity is closely tied to spatial clustering and varies by age group and region. These findings suggest the need for regional migration patterns that effectively respond to demographic imbalances and support balanced regional development.

2. Analysis Result

Five models were constructed to investigate the effects of economic opportunity and residential substitutability on interregional migration across different life cycle stages. For each model, the spatial weight matrix (W_{ij}) was constructed using a contiguity-based weighting matrix that reflects spatial relationships between areas in terms of both residential substitutability and economic opportunity. These effects were applied exclusively to the outcome variables. The main effects were analyzed by life cycle stage, and the results are presented in 〈Table 3〉 as Bayesian posterior probabilities. The results of the in-migration and out-migration models are shown in 〈Tables 4 and 5〉, respectively.

Through the comparison of Bayesian posterior probabilities, the results of this study suggest that interregional migration may be influenced by areas adjacent to both the origin and destination areas. The analysis indicates that Model 1, which assumes spatial dependence, is more appropriate than Model 0, which assumes there is no spatial dependence between areas. These findings imply that the

Table 3. Bayesian posterior probabilities by model

Models	Posterior probabilities of different models (Log-marginal)				
	Total	Young adult	Family formation	Child-education	Middle-aged
			In-migration intensity		
Model 0	0.000 (-4490.04)	0.000 (-5016.61)	0.000 (-5103.43)	0.000 (-4239.49)	0.000 (-3520.22)
Model 1	0.032 (-4479.98)	0.233 (-5128.31)	0.093 (-5091.41)	0.037 (-4232.74)	0.147 (-3507.80)
Model 2	**0.906 (-4476.64)**	0.125 (-5128.93)	0.276 (-5090.31)	0.363 (-4230.45)	**0.369 (-3506.88)**
Model 3	0.007 (-4481.44)	**0.560 (-5127.43)**	0.277 (-5090.30)	0.069 (-4232.11)	0.229 (-3507.36)
Model 4	0.055 (-4479.45)	0.082 (-5129.35)	**0.354 (-5090.06)**	**0.531 (-4230.07)**	0.255 (-3507.25)
			Out-migration intensity		
Model 0	0.000 (-3687.90)	0.000 (-4590.91)	0.000 (-4213.39)	0.000 (-3263.11)	0.000 (-2621.14)
Model 1	0.038 (-3644.56)	0.191 (-4555.33)	**0.825 (-4196.65)**	0.081 (-3242.62)	**0.719 (-2566.09)**
Model 2	**0.962 (-3641.33)**	**0.776 (-4553.93)**	0.129 (-4198.51)	**0.902 (-3240.21)**	0.246 (-2567.16)
Model 3	0.000 (-3662.87)	0.005 (-4558.99)	0.038 (-4199.74)	0.003 (-3246.03)	0.027 (-2569.37)
Model 4	0.000 (-3660.35)	0.028 (-4557.24)	0.008 (-4201.29)	0.014 (-3244.34)	0.008 (-2570.59)

Table 4. In-migration intensity results

Variables	Model 0	Model 1	Model 2	Model 3	Model 4
	Coef.	Coef.	Coef.	Coef.	Coef.
Total in-migration intensity					
Population density	0.567**	0.607**	0.604**	0.605**	0.602**
GRDPPC	0.147**	0.125*	0.121*	0.127*	0.125*
Creative-class ratio	0.066	0.061	0.060	0.060	0.060
Educational attainment	0.017	0.072	0.073	0.063	0.062
Average land price	0.104*	0.094*	0.095*	0.093*	0.094*
Local development budget ratio	0.054***	0.053***	0.052***	0.052***	0.052***
Secondary industry change	0.002	0.002	0.002	0.002	0.002
Tertiary industry change	0.033***	0.033***	0.033***	0.033***	0.033***
Spatial rho (ρ)	-	0.157***	0.168***	0.138***	0.139***
Log-likelihood AIC/BIC	-4080.99 8177.98/8223.76	-4068.15 8156.44/8213.67	-4064.20 8148.56/8205.79	-4069.92 8159.96/8217.19	-4067.58 8155.31/8212.54
Young adult in-migration intensity					
Population density	-0.016	0.278	0.262	0.313	0.290
GRDPPC	0.031	0.026	0.026	0.025	0.027
Creative-class ratio	0.104*	0.100*	0.098*	0.093*	0.093*
Educational attainment	0.621***	0.670***	0.660***	0.681***	0.670***
Average land price	0.404***	0.339***	0.345***	0.342***	0348***
Local development budget ratio	0.036*	0.032*	0.031*	0.029*	0.028
Secondary industry change	-0.002	-0.001	-0.002	0.002	0.002
Tertiary industry change	-0.004	-0.001	-0.001	0.001	0.000
Spatial rho (ρ)	-	0.261***	0.250***	0.250***	0.235***
Log-likelihood AIC/BIC	-4832.35 9680.70/9726.49	-4793.31 9606.85/9664.08	-4794.00 9608.27/9665.50	-4792.31 9604.89/9662.12	-4794.56 9609.36/9666.60
Family formation in-migration intensity					
Population density	0.496	0.566*	0.550*	0.557*	0.549*
GRDPPC	0.284***	0.258***	0.260***	0.259***	0.259***
Creative-class ratio	-0.002	-0.002	-0.002	-0.003	-0.003
Educational attainment	0.020	0.046	0.045	0.051	0.052
Average land price	0.292***	0.253***	0.258***	0.247***	0.248***
Local development budget ratio	0.040*	0.040**	0.040**	0.040**	0.039**
Secondary industry change	-0.011	-0.010	-0.010	-0.010	-0.010
Tertiary industry change	0.027**	0.028**	0.028**	0.028**	0.028**
Spatial rho (ρ)	-	0.164***	0.149***	0.162***	0.161***
Log-likelihood AIC/BIC	-4768.28 9552.56/9598.35	-4753.14 9526.43/9583.66	-4752.02 9523.84/9581.07	-4751.88 9523.93/9581.16	-4751.60 9523.33/9580.56
Child-education in-migration intensity					
Population density	0.554*	0.576**	0.570**	0.547*	0.542*
GRDPPC	0.140*	0.124	0.120	0.123	0.122
Creative-class ratio	-0.015	-0.016	-0.015	-0.016	-0.015
Educational attainment	-0.051	-0.039	-0.036	-0.032	-0.030

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Variables	Model 0	Model 1	Model 2	Model 3	Model 4
	Coef.	Coef.	Coef.	Coef.	Coef.
Average land price	0.086	0.077	0.077	0.075	0.075
Local development budget ratio	0.042**	0.041**	0.040**	0.041**	0.041**
Secondary industry change	-0.008	-0.007	-0.007	-0.007	-0.007
Tertiary industry change	0.037***	0.037***	0.037***	0.038***	0.037***
Spatial rho (ρ)	-	0.132***	0.149***	0.131***	0.137***
Log-likelihood AIC/BIC	-3800.26 7616.52/7662.30	-3791.31 7602.73/7659.96	-3788.60 7597.31/7654.55	-3790.58 7601.29/7658.53	-3788.17 7596.49/7653.72
Middle-aged in-migration intensity					
Population density	0.809**	0.835**	0.832**	0.822**	0.818**
GRDPPC	-0.012	-0.036	-0.038	-0.032	-0.032
Creative-class ratio	0.070	0.078	0.076	0.076	0.075
Educational attainment	0.451***	0.480***	0.478***	0.487***	0.484***
Average land price	-0.034	-0.018	-0.016	-0.023	-0.022
Local development budget ratio	0.053**	0.054**	0.053**	0.053**	0.052**
Secondary industry change	-0.008	-0.008	-0.008	-0.008	-0.008
Tertiary industry change	0.025*	0.024*	0.024*	0.025*	0.025*
Spatial rho (ρ)	-	0.169***	0.170***	0.161***	0.156***
Log-likelihood AIC/BIC	-2994.33 6004.66/6050.44	-2978.71 5977.56/6034.79	-2977.60 5975.36/6032.59	-2978.20 5976.57/6033.80	-2978.06 5976.29/6033.52

N=2,260, *** p<0.01, ** p<0.05, * p<0.1

Table 5. Out-migration intensity results

Variables	Model 0	Model 1	Model 2	Model 3	Model 4
	Coef.	Coef.	Coef.	Coef.	Coef.
Total out-migration intensity					
Population density	-0.756***	-0.790***	-0.779***	-0.734***	-0.730***
GRDPPC	0.077	0.068	0.066	0.072	0.071
Creative-class ratio	0.051	0.048	0.047	0.050	0.049
Educational attainment	-0.044	0.008	-0.009	-0.016	-0.030
Average land price	-0.146***	-0.118**	-0.118**	-0.123**	-0.124**
Local development budget ratio	-0.014	-0.017	-0.018	-0.017	-0.018
Secondary industry change	0.015*	0.013*	0.012*	0.013*	0.013*
Tertiary industry change	0.017**	0.017**	0.016**	0.017**	0.017**
Spatial rho (ρ)	-	0.301***	0.289***	0.266***	0.239***
Log-likelihood AIC/BIC	-3182.22 6380.44/6426.22	-3130.20 6280.69/6337.92	-3126.48 6273.28/6330.51	-3136.97 6294.22/6351.45	-3136.49 6293.18/6350.42
Young adult out-migration intensity					
Population density	-1.150**	-1.123***	-1.107***	-1.090***	-1.083***
GRDPPC	0.061	0.055	0.056	0.059	0.060
Creative-class ratio	-0.075*	-0.059	-0.061	-0.060	-0.062
Educational attainment	0.709***	0.607***	0.586***	0.614***	0.603***
Average land price	-0.246***	-0.184***	-0.185***	-0.192***	-0.195***

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Variables	Model 0	Model 1	Model 2	Model 3	Model 4
	Coef.	Coef.	Coef.	Coef.	Coef.
Local development budget ratio	-0.048***	-0.047***	-0.049***	-0.048***	-0.049***
Secondary industry change	0.025***	0.022**	0.022**	0.022**	0.022**
Tertiary industry change	0.005	0.006	0.006	0.007	0.007
Spatial rho (ρ)	-	0.259***	0.258***	0.237***	0.227***
Log-likelihood AIC/BIC	-4194.02 8404.03/8449.82	-4151.33 8322.90/8380.13	-4149.63 8319.52/8376.75	-4155.60 8331.45/8388.69	-4153.54 8327.31/8384.54
Family formation out-migration intensity					
Population density	-1.588***	-1.612***	-1.600***	-1.585***	-1.579***
GRDPPC	0.155***	0.150***	0.155***	0.154***	0.158***
Creative-class ratio	-0.025	-0.014	-0.015	-0.013	-0.015
Educational attainment	0.113	0.071	0.062	0.070	0.065
Average land price	-0.166***	-0.151***	-0.153***	-0.157***	-0.159***
Local development budget ratio	-0.032**	-0.032**	-0.033**	-0.032**	-0.032**
Secondary industry change	0.025***	0.023***	0.023***	0.023***	0.023***
Tertiary industry change	0.007	0.007	0.007	0.007	0.007
Spatial rho (ρ)	-	0.191***	0.180***	0.162***	0.149***
Log-likelihood AIC/BIC	-3771.02 7558.03/7603.81	-3750.32 7520.80/7578.04	-3752.46 7525.10/7582.33	-3754.00 7528.15/7585.38	-3755.79 7531.75/7588.98
Child-education out-migration intensity					
Population density	-1.556***	-1.588***	-1.572***	-1.566***	-1.555***
GRDPPC	0.136**	0.127**	0.129**	0.128**	0.131**
Creative-class ratio	-0.029	-0.016	-0.014	-0.015	-0.014
Educational attainment	0.181*	0.145*	0.132	0.141	0.134
Average land price	-0.197***	-0.182***	-0.182***	-0.181***	-0.182***
Local development budget ratio	-0.047***	-0.048***	-0.049***	-0.048***	-0.049***
Secondary industry change	0.015	0.014	0.014	0.015*	0.015*
Tertiary industry change	0.008	0.007	0.006	0.007	0.007
Spatial rho (ρ)	-	0.216***	0.212***	0.192***	0.184***
Log-likelihood AIC/BIC	-2706.25 5428.50/5474.29	-2681.10 5382.40/5439.63	-2678.253 5376.71/5433.94	-2685.23 5390.53/5447.76	-2683.19 5368.57/5443.80
Middle-aged out-migration intensity					
Population density	-1.318***	-1.343***	-1.321***	-1.299***	-1.290***
GRDPPC	-0.011	-0.025	-0.023	-0.016	-0.015
Creative-class ratio	0.062	0.082**	0.082**	0.084**	0.084**
Educational attainment	0.489***	0.460***	0.448***	0.459***	0.452***
Average land price	-0.232***	-0.175***	-0.177***	-0.177***	-0.180***
Local development budget ratio	-0.035**	-0.039***	-0.040***	-0.040***	-0.041***
Secondary industry change	0.014	0.011	0.011	0.012	0.012
Tertiary industry change	0.009	0.007	0.007	0.008	0.008
Spatial rho (ρ)	-	0.330***	0.314***	0.301***	0.281***
Log-likelihood AIC/BIC	-1986.93 3989.86/4035.64	-1921.18 3862.69/3919.92	-1922.37 3865.08/3922.31	-1925.19 3870.68/3927.91	-1926.54 3873.41/3930.64

N=2,260, *** p<0.01, ** p<0.05, * p<0.1

migration patterns are better understood when considering the influence of residential substitutability and economic opportunities. Furthermore, the results show that the model's fit improves when considering multiple factors simultaneously rather than focusing on a single influence. This suggests that migration is not driven by a single factor, but rather by the interaction of multiple complex influences. However, since the analysis is based on panel data from a specific period, its validity is limited to that period.

Considering both the effects of economic opportunity and residential substitutability simultaneously improves the model's fit. For instance, regarding the in-migration intensity of the child-education group, Model 4 (0.531) was found to be more effective in explaining population inflow between regions than Models 2 (0.363) or 3 (0.069), as it accounts for both effects simultaneously. The final spatial spillover effect is determined by the intensity of spatial dependence (ρ), which is associated with the complex spatial effect ($w_{ij}^{se} = w_{ij}^{s} \circ w_{ij}^{e}$). Thus, Model 4, which considers economic opportunity and residential substitutability simultaneously, is the most appropriate model. These simultaneous effects also yielded similar results for the population inflow in the family formation group.

However, the results may vary depending on the spatial influence of residential substitutability and economic opportunities as applied to different life cycle stages. Most models demonstrated an improved fit when considering the impact of residential substitutability on migration patterns across different life cycle stages. This suggests that individuals tend to select alternative places of residence based on regional similarities, such as housing costs, commuting patterns, living convenience, and public services. Notably, the effects of residential substitutability on the inflow and outflow of the total population were particularly significant. This indicates that interregional migration generally occurs with consideration of job-housing similarity between regions. Although isolating the effects of population attraction and propelling factors when accounting for residential substitutability is challenging, the analysis indicates that residential substitutability must be adequately considered to more comprehensively explain migration systems. Specifically, residential substitutability, as measured using commuting data, reflects the balance between residential locations and job accessibility. This indicates that migration commonly occurs toward areas with similar job accessibility. While residential substitutability does not directly reveal the direction of migration flows, its influence is incorporated into the spatial weight matrix to better explain spatial migration dynamics. Additionally, this modeling approach enables assessing whether single or simultaneous effects better explain migration patterns (Kim et al., 2025). For example, regarding young adult population inflows, the results suggest that considering a single effect rather than simultaneous effects provides a more accurate model. Findings from Model 3 (0.560), which incorporated economic opportunity, suggest that economic opportunity is the most significant factor in attracting young adults. This result aligns with the tendency of young people to migrate to metropolitan areas or large cities in search of economic opportunities.

In some cases, the fit of the model may not improve compared to Model 1, which accounts for spatial dependence, even when spatial effects related to residential substitutability and economic opportunity are included. According to the results, the model incorporating spatial effects of residential substitutability and economic opportunity demonstrates a better fit than the model considering only spatial dependence in the case of population inflow. Among the population outflow models, however, the Bayesian posterior probabilities for family formation and middle-aged population outflow were 0.825 and 0.719, respectively. This indicates that the model accounting solely for spatial dependence yielded a better fit. These results suggest that households tend to migrate shorter distances rather than longer ones and highlight the need for a deeper understanding of policy and structural changes that cannot be fully explained by socioeconomic factors alone.

Most of the predictors used in this study were found to have a statistically significant direct effect on migration intensity. Specifically, regional population density, land prices, and local development budgets were found to positively affect in-migration intensity and negatively affect out-migration intensity. Regions with higher population density and land prices tend to have better-developed infrastructure. Areas with a larger share of development-related budgets, such as those allocated for water resource development, regional and urban development, and industrial complex development, typically prioritize infrastructure improvement. These characteristics suggest that such regions are more likely to attract and retain a population.

Additionally, educational attainment was found to significantly impact in- and out-migration intensities. This implies that regions with higher levels of education are more likely to experience increased mobility because highly educated individuals tend to seek better opportunities elsewhere. This finding aligns with the arguments of Faggian et al. (2017) and Winters (2011), who emphasize the mobility of highly educated populations. Among young adults, in particular, the proportion of the creative class (a proxy for human capital) significantly affected in-migration. This corresponds with Higa et al. (2019), who found that regions with a high concentration of highly skilled workers tend to attract more diverse industries and populations. These findings suggest that young people are drawn not only by job opportunities or cost-of-living advantages, but also by connections to knowledge-based industries and innovation infrastructure.

From an industrial structural perspective, a higher tertiary sector share was significantly associated with in-migration, while a higher secondary sector share was associated with out-migration. This pattern reflects the accelerating deindustrialization of urban manufacturing and the broader transition toward a service-oriented economy. This transformation may lead to increased rural-to-urban migration, which could exacerbate population decline in some non-urban areas.

Most importantly, this study finds that migration decisions are driven not only by socioeconomic disparities between regions but also by spatial relationship structures that cannot be captured by absolute differences alone. The analysis incorporates a spatial weight matrix reflecting non-physical linkages, such as residential substitutability and disparities in economic opportunity, to capture the spatial interdependencies among regions. Even within the relational framework previously established, significant spatial effects were identified. These effects indicate that migration is influenced by the intricate interplay of life cycle stages and interregional connectivity. This influence is more complex than a simple linear movement toward “better” areas.

This study provides empirical evidence that interregional migration is shaped by multi-layered processes involving spatial interdependencies and life-cycle-specific dynamics, rather than being driven solely by regional socioeconomic disparities. Integrating migration theory, spatial effects, and a life-cycle perspective, the study offers a comprehensive understanding of interregional migration mechanisms. Specifically, the study examines the spatial effects of residential substitutability and economic opportunity, emphasizing their simultaneous influence across life cycle stages. Through comparative modeling with alternative spatial weight matrices, the study reveals how spatial interactions impact migration patterns. Due to the consistent statistical relationships between the outcome and predictor variables across the models, the focus of the interpretation shifts from individual predictors to broader structural dynamics. The following discussion derives policy implications based on the results of the analysis.

V. Discussion and Conclusion

One of the core tasks in migration research is identifying the complex factors influencing migration. South Korea is facing an inevitable population decline due to population aging and low birth rates. Additionally, the nature of competitive regional population attraction is causing an increasing population concentration in metropolitan areas, which is accelerating the extinction of rural areas and further exacerbating population imbalances. Understanding the multifaceted impacts of migration, especially under conditions of limited resources and capital, can provide more practical insights into spatial balance and offer strategic directions for addressing population decline. Therefore, this study proposes a model based on simultaneous spatial impacts that more accurately reflects spatial migration relationships in the modeling process. The findings suggest that migration should be viewed as a spatial phenomenon involving regional disparities, residential substitutability, and economic opportunities. This helps us better understand the complex decision-making mechanisms behind migration.

This study assumes that interregional migration occurs due to spatial dependence, similarity, and the gravitational influence of economic opportunities. Because Korea’s industries, economic development, population, education, and infrastructure are concentrated in a few metropolitan areas, it is difficult to implement policies aimed at attracting populations from multiple areas with similar levels of competitiveness, as would be possible in countries with a more evenly decentralized structure. Therefore, it is imperative to understand the migration dynamics occurring under the strong gravitational influence of Seoul and a few other major metropolitan areas and to derive policy implication based on this context. This study aims to identify in detail the multifaceted spatial interactions of migration occurring within this spatial framework in South Korea.

To improve our understanding of the complex relationship between residential substitutability and economic opportunities in interregional migration, we carefully identified and analyzed spatial interactions. During migration, individuals compare the utility differences across multiple alternative regions to maximize their well-being, considering both economic and non-economic factors (Biagi et al., 2011). In reality, migration is unlikely to be determined by a single factor. Rather, various determinants interact in a complex way to influence the selection of the final destination (Castelli, 2018). However, the complex interdependencies among migration determinants have not been extensively addressed in the existing literature. This study emphasizes the simultaneous interaction between the spatial relationships driving migration–specifically, residential substitutability and the gravitational influence of economic opportunities–rather than treating migration determinants individually, as is typically done in the existing research (Cavalleri et al., 2021; Higa et al., 2019; Winters, 2011). The main findings of this study underscore the importance of understanding these complex spatial interactions. They demonstrate that the simultaneous influence of multiple spatial relationships provides the most comprehensive explanation of interregional migration systems.

The results suggest that residential substitutability plays a more significant role in explaining the interregional migration system. Individuals tend to prioritize the balance between housing availability and employment opportunities when deciding to migrate. They also consider connectivity between real-life locations and labor markets. These factors cannot be fully captured by spatial dependence alone. This phenomenon notably impacts various populations and life cycles, offering a more substantial explanation for migration patterns than spatial dependence. Inter-regional spatial relationships derived from commuting data can offer strategic insights for mitigating the concentration of employment opportunities in specific regions. Considering residential substitutability, policies can encourage distributed development.

However, this phenomenon is likely to be confined to large cities and their surrounding areas. It may not effectively address the population decline occurring in non-metropolitan areas. This study's findings indicate that the primary driver of young people's migration is economic opportunity disparity. The simultaneous influence of residential substitutability and economic opportunity is the main factor during the family formation and child-education stages. Young adults exhibit the highest levels of migration intensity (Cavalleri et al., 2021) and tend to migrate farther than other age groups, often moving regardless of geographical distance (Biagi et al., 2011). While residential substitutability, based on commuting patterns, is somewhat dependent on physical distance (Rincke, 2010), economic opportunity can be considered a factor that transcends geographic distance. In this context, the analysis provides empirical evidence that young adults primarily migrate in pursuit of economic opportunities rather than geographic proximity. To promote balanced regional development, policies that relocate jobs to non-metropolitan areas or the outskirts of large cities could serve as a strategy to mitigate the concentration of young populations in metropolitan areas.

Migration is a dynamic process shaped not by a single factor but by the simultaneous and complex interplay of multiple factors, whose composition and relative importance vary across generations. Accordingly, this study empirically identifies the key drivers of migration at each stage of the life cycle, highlighting the need for differentiated population and spatial policy design.

This study moves beyond conventional approaches that focus primarily on the determinants of population inflow or outflow. It emphasizes the necessity of a comprehensive spatial strategy that reflects the heterogeneity and interaction structure of migration determinants by life cycle stage. For young adults, creating sustainable and high-quality employment opportunities within the region is a primary challenge. For individuals in the family formation and child-education stages, policy priorities should center on housing stability, educational access, and care infrastructure provision. Integrated planning that considers these factors holistically can contribute to building a flexible settlement base that accommodates cyclical patterns of migration by age group.

Notably, South Korea's current regional balanced development policies have traditionally emphasized physical infrastructure investment in lagging-behind regions, along with spatial decentralization strategies such as restricting in-migration to the Seoul metropolitan area and relocating public institutions. However, this study argues that such approaches are insufficient to address the structural drivers of migration. By focusing on life cycle-specific socioeconomic motivations and the functional connectivity between residential and employment spaces, the study highlights the need for a policy paradigm shift. To support this, residential substitutability and economic opportunity indices were developed and empirically tested, confirming their influence on migration patterns. Based on these findings, the study suggests two strategic directions for policy intervention: first, promoting functionally integrated development across metropolitan commuting zones by strengthening connections between housing and employment through expanded transit networks and suburban-industrial linkages; and second, establishing life cycle responsive spatial strategies, such as integrating young adults' housing with job clusters and providing comprehensive community infrastructure, such as education, childcare, and health care for families. These approaches aim not merely at redistributing population but at enhancing residential viability and quality of life, offering a more sustainable foundation for balanced regional development.

In terms of scholarly contributions, this study differs from previous research by showing that migration decisions are shaped by combinations of multidimensional factors and their interaction structures rather than by the impact of single variables. These structures operate differently by the age group. Instead of isolating the role of a single determinant, this study focuses on the structural coupling of economic opportunity and residential substitutability in the migration decision-making process. This approach provides empirical evidence for designing life-stage-specific policy interventions. Spatial econometric studies have shown that the choice of spatial weight matrices can significantly influence interpretation (Anselin, 2002; Elhorst and Halleck Vega, 2017; Jeong, 2024; Kim et al., 2025). Thus, this study underscores that the construction of migration factors and the modeling of their interactions can critically shape policy implications. Rather than merely replicating past comparative analyses of spatial weights, this approach advances a framework that reflects the simultaneous effects of migration drivers. This framework demonstrates the interpretive significance of spatial weight specification as a starting point for policy-relevant analysis.

In some cases, spatial dependence has been shown to be a more effective explanation of migration patterns than residential substitutability or economic opportunity. This study focuses on a period of stagnant population growth, during which metropolitan areas experienced population decline due to suburbanization, while non-metropolitan areas simultaneously depopulated. Since population stagnation and decline are evident and suburbanization is widespread, the determinants of migration in this context may differ from those anticipated during periods of population growth. Model 1, which uses spatial weights based on physical proximity, indicates a high posterior probability of population outflow among the family formation and middle-aged groups. This may be the result of government policies aimed at dispersing the population, such as relocating industrial facilities to surrounding areas and promoting decentralization (Lee and Kim, 2020). During the family formation period, household demand for housing increases due to marriage, childbirth, and child-rearing. However, high housing prices and living expenses in urban areas often prompt households to move to suburbs. Furthermore, migration to suburban areas, which offer larger residences and more pleasant environments (e.g., green spaces and better air quality), may be preferred during middle age. In highly urbanized areas like Seoul, population outflow is also observed as a result of suburbanization policies (Joo and Seo, 2018). This suggests that suburbanization itself may be a key determinant of migration.

Due to the controversial nature of migration research (Piras, 2017), the spatial impacts related to residential substitutability and economic opportunities may vary according to regional and local policies, as well as across different national and regional contexts. Therefore, further empirical research is required to explore these variations more comprehensively. Since this study analyzes population subgroups based on life cycle stages, its results only show general trends. To address this limitation, future research should consider more detailed individual and group characteristics.

Additionally, there may be other spatial effects of migration that are not fully captured by the residential substitutability and economic opportunity, which are the two factors considered in this study. Although the analysis is conducted at the si, gun, and gu levels across the entire country to ensure consistency in spatial scope, this approach inherently limits the ability to capture the structural and collective influence of specific regional clusters, such as metropolitan areas or capital regions. The cumulative effect of urban agglomerations on adjacent non-urban regions may be more significant than the influence of individual urban areas (Maza and Villaverde, 2011). This can be interpreted in the context of the spatial spillover effects of agglomeration economies.

This study does not directly capture the structural effects of regional clusters. However, we partially address this limitation by incorporating the concept of simultaneous spatial effects to reflect the interaction structures between regions (Kim et al., 2025). However, future research should consider applying heterogeneous spatial models and region-type-specific analytical framework to more accurately account for the structural heterogeneity in migration determinants between the capital region and non-capital areas, as well as differences in institutional and demographic contexts across regions. Incorporating local contexts, such as capital region concentration, regional depopulation, and the impacts of innovation city policies, will be essential for deriving more realistic and granular spatial policy implications. Furthermore, future studies should conduct a comparative analysis of multiple spatial econometric models, such as SEM, SDM, and SDEM, to more thoroughly identify the structural characteristics of spatial dependence and their implications. This approach would contribute to a deeper theoretical and empirical understanding of the mechanisms of spatial interactions in migration dynamics, going beyond the technical choice of spatial weights.

This study explores the simultaneous spatial effects of migration and examines how migration determinants change throughout the life cycle. We emphasize that key migration determinants vary throughout the life cycle and that migration should be understood within the context of complex, interdependent spatial relationships.

References

1. Anselin, L., 2002. "Under the Hood Issues in the Specification and Interpretation of Spatial Regression Models", *Agricultural Economics*, 27(3): 247-267.
2. Bayer, P., Keohane, N., and Timmins, C., 2009. "Migration and Hedonic Valuation: The Case of Air Quality", *Journal of Environmental Economics and Management*, 58(1): 1-14.
3. Bell, M., Charles-Edwards, E., Ueffing, P., Stillwell, J., Kupiszewski, M., and Kupiszewska, D., 2015. "Internal Migration and Development: Comparing Migration Intensities around the World", *Population and Development Review*, 41(1): 33-58.
4. Bernard, A. and Bell, M., 2018. "Educational Selectivity of Internal Migrants: A Global Assessment", *Demographic Research*, 39(29): 835-854.
5. Bernard, A., Bell, M., and Charles-Edwards, E., 2014. "Life-Course Transitions and the Age Profile of Internal Migration", *Population and Development Review*, 40(2): 213-239.
6. Bertoli, S. and Moraga, J.F.H., 2013. "Multilateral Resistance to Migration", *Journal of Development Economics*, 102: 79-100.
7. Biagi, B., Faggian, A., and McCann, P., 2011. "Long and Short Distance Migration in Italy: The Role of Economic, Social and Environmental Characteristics", *Spatial Economic Analysis,* 6(1): 111-131.
8. Boarnet, M.G., 1998. "Spillovers and the Locational Effects of Public Infrastructure", *Journal of Regional Science*, 38(3): 381-400.
9. Bonifazi, C., Heins, F., Licari, F., and Tucci, E., 2021. "The Regional Dynamics of Internal Migration Intensities in Italy", *Population, Space and Place*, 27(7): e2331.
10. Bu, Y., Wang, E., Qiu, Y., and Möst, D., 2022. "Impact Assessment of Population Migration on Energy Consumption and Carbon Emissions in China: A Spatial Econometric Investigation", *Environmental Impact Assessment Review*, 93: 106744.
11. Castelli, F., 2018. "Drivers of Migration: Why Do People Move?", *Journal of Travel Medicine*, 25(1): 1-7.
12. Cavalleri, M.C., Luu, N., and Causa, O., 2021. *Migration, Housing and Regional Disparities: A Gravity Model of Inter-Regional Migration with an Application to Selected Oecd Countries,* OECD Economics Department Working Papers, 1691. Paris:OECD Publishing.
13. Choi, Y., Kim, Y.M., and Cho, S.H., 2010. "The Analysis on the Characteristics of Residential Mobility by Life-Cycle", *Journal of the Korean Society of Civil Engineers D*, 30(3): 313-321.
14. de Haas, H., 2021. "A Theory of Migration: The Aspirations-Capabilities Framework", *Comparative Migration Studies*, 9: 8.
15. de Jong, P.A., 2022. "Later-Life Migration in The Netherlands:

Propensity to Move and Residential Mobility", *Journal of Aging and Environment*, 36(1): 16-39.

16. Dubé, J. and Legros, D., 2013. "A Spatio-temporal Measure of Spatial Dependence: An Example Using Real Estate Data", *Papers in Regional Science*, 92(1): 19-30.
17. Elhorst, J.P. and Halleck Vega, S., 2017. "The SLX Model: Extensions and the Sensitivity of Spatial Spillovers to W", *Papeles de Economía Española*, 152: 34-50.
18. Elhorst, J.P., 2014. *Spatial Econometrics: From Cross-Sectional Data to Spatial Panels*, Heidelberg: Springer.
19. Etzo, I., 2011. "The Determinants of the Recent Interregional Migration Flows in Italy: A Panel Data Analysis", *Journal of Regional Science*, 51(5): 948-966.
20. Faggian, A., Rajbhandari, I., and Dotzel, K.R., 2017. "The Interregional Migration of Human Capital and Its Regional Consequences: A Review", *Regional Studies*, 51(1): 128-143.
21. Finnie, R., 2004. "Who Moves? A Logit Model Analysis of Inter-Provincial Migration in Canada", *Applied Economics*, 36(16): 1759-1779.
22. Firmino Costa da Silva, D., Elhorst, J.P., and Silveira Neto, R.D.M., 2017. "Urban and Rural Population Growth in a Spatial Panel of Municipalities", *Regional Studies*, 51(6): 894-908.
23. Florida, R., 2002. *The Rise of the Creative Class (Vol. 9)*, New York: Basic Books.
24. Florida, R., Mellander, C., and Stolarick, K., 2008. "Inside the Black Box of Regional Development—human capital, the Creative Class and Tolerance", *Journal of Economic Geography*, 8(5): 615-649.
25. Fratesi, U. and Percoco, M., 2014. "Selective Migration, Regional Growth and Convergence: Evidence from Italy", *Regional Studies*, 48(10): 1650-1668.
26. Fratesi, U. and Riggi, M.R., 2007. "Does Migration Reduce Regional Disparities? The Role of Skill-Selective Flows", *Review of Urban and Regional Development Studies*, 19(1): 78-96.
27. Glumac, B., Herrera-Gomez, M., and Licheron, J., 2019. "A Hedonic Urban Land Price Index", *Land Use Policy*, 81: 802-812.
28. Haas, A. and Osland, L., 2014. "Commuting, Migration, Housing and Labour Markets: Complex Interactions", *Urban Studies*, 51(3): 463-476.
29. Higa, K., Nonaka, R., Tsurumi, T., and Managi, S., 2019. "Migration and Human Capital: Evidence from Japan", *Journal of the Japanese and International Economies*, 54: 101051.
30. Hollenbach, F.M. and Montgomery, J.M., 2020. "Bayesian Model Selection, Model Comparison, and Model Averaging", In *The Sage Handbook of Research Methods in Political Science and International Relations*, 937-960, Sage.
31. Hong, S.H. and Yoo, S.Y., 2012. "Determinants of Interregional Migration by Age Cohort among Korean Cities, Counties or Wards", *Seoul Studies*, 13(1): 1-19.
32. Hunt, J., 2004. "Are Migrants More Skilled than Non-Migrants? Repeat, Return, and Same-employer Migrants", *Canadian Journal of Economics/Revue Canadienne d'économique*, 37(4): 830-849.
33. Jeong, J. and Gim, T.H.T., 2023. "The Effects of the Local and Regional Conditions and Inequalities on Urban Shrinkage: A Multilevel Analysis Focusing on Local Population Decline", *Urban Research & Practice*, 16(3): 438-457.
34. Jeong, J., 2024. "Discontinuities in Regional Economic Development Due to Administrative Boundaries: Examining the Mechanisms of the Boundary Effect", *Environment and Planning B: Urban Analytics and City Science*, 51(6): 1227-1247.
35. Jeong, K.S. and Hong, S.H., 2019. "A Study on the Influential Factors of Population Influx into the Capital Region by Spatial Analysis -GIS and Geographically Weighted Regression-", *Journal of Korea Planning Association*, 54(6): 116-127.
36. Joo, Y.M. and Seo, B., 2018. "Dual Policy to Fight Urban Shrinkage: Daegu, South Korea", *Cities*, 73: 128-137.
37. Karemera, D., Oguledo, V.I., and Davis, B., 2000. "A Gravity Model Analysis of International Migration to North America", *Applied Economics*, 32(13): 1745-1755.
38. Kim, L.Y. and Yang, K.S., 2013. "Empirical Analysis of Regional Characteristic Factors Determining Net Inflow and Outflow of the Population", *Journal of the Korean Regional Development Association*, 25(3): 1-20.
39. Kim, W., Jeong, J., and Yoon, D.K., 2025. "Analysis of Multiple Gravitational Influences on Interregional Population Migration in South Korea", *Regional Studies*, 59(1): 2385560.
40. Koo, Y.M. 2021. "Regional Disparities in Population Change and Urban Decline: Implications for the Low Fertility and Disappearing Region Issues", *The Geographical Journal of Korea*, 55(3): 301-320.
41. Kulu, H., Lundholm, E., and Malmberg, G., 2018. "Is Spatial Mobility on the Rise or in Decline? An Order-specific Analysis of the Migration of Young Adults in Sweden", *Population Studies*, 72(3): 323-337.
42. Laajimi, R. and Le Gallo, J., 2022. "Push and Pull Factors in Tunisian Internal Migration: The Role of Human Capital", *Growth and Change*, 53(2): 771-799.
43. Lee, E.S., 1966. "A Theory of Migration", *Demography*, 3(1): 47-57.
44. Lee, H.Y., 2008. *Development of the Extended Migration Model and Its Empirical Analysis,* Korea Research Institute for Human Settlements.
45. Lee, J.S. and Won, J.W. 2017. "An Investigation into the Attributes and Causes of Residential Mobility in the Seoul Metropolitan Region: Household Mobility between 2001 and 2010", *Journal of Korea Planning Association*, 52(5): 27-45.
46. Lee, S.L. and Choi, I.S., 2023. *Current Internal Migration Trends and Policy Recommendations for Demographic Strategies in Korea*, Korea Institute for Health and Social Affairs.
47. Lee, S.L., 2009. "Age Effects on Migration Schedule: Primary, Repeat and Return Migration", *Korea Journal of Population Studies*, 32(3): 43-72.

48. Lee, Y.J. and Kim, D.S., 2020. "Internal Migration in South Korea", *Internal Migration in the Countries of Asia: A Cross-national Comparison*, 93-111.

49. LeSage, J.P. and Pace, R.K., 2008. "Spatial Econometric Modeling of Origin-destination Flows", *Journal of Regional Science*, 48(5): 941-967.

50. LeSage, J.P., 2014. "Spatial Econometric Panel Data Model Specification: A Bayesian Approach", *Spatial Statistics*, 9: 122-145.

51. Longino Jr, C.F., Bradley, D.E., Stoller, E.P., and Haas III, W.H., 2008. "Predictors of Non-local Moves among Older Adults: A Prospective Study", *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 63(1): S7-S14.

52. Lowry, I.S., 1966. *Migration and Metropolitan Growth: Two Analytical Models*, Chandler Publishing Company.

53. Maza, A. and Villaverde, J., 2011. "EU Regional Convergence and Policy: Does the Concept of Region Matter?", *Journal of Policy Modeling*, 33(6): 889-900.

54. McDuff, D., 2011. "Demand Substitution across US Cities: Observable Similarity and Home Price Correlation", *Journal of urban Economics*, 70(1): 1-14.

55. Mulder, C.H. and Hooimeijer, P., 1999. "Residential Relocations in the Life Course", *Population Issues*, 159-186.

56. Mur, J. and Angulo, A., 2009. "Model Selection Strategies in a Spatial Setting: Some Additional Results", *Regional Science and Urban Economics*, 39(2): 200-213.

57. Nam, H.G. and Seo, W.S., 2018. "Analyzing Features of Outflow Household in Local Small and Medium sized Declining Cities", *Journal of Korea Planning Association*, 53(4): 57-70.

58. Osborne, J., 2002. "Notes on the Use of Data Transformations", *Practical Assessment, Research, and Evaluation*, 8(1): 6.

59. Parent, O. and LeSage, J.P., 2008. "Using the Variance Structure of the Conditional Autoregressive Spatial Specification to Model Knowledge Spillovers", *Journal of applied Econometrics*, 23(2): 235-256.

60. Park, J.K. and Kim, D.H., 2020. *Research on Promoting Young Influx and Settlement Support Policies in Response to Population Decline,* Korea Research Institute for Local Administration.

61. Piras, R., 2017. "A Long-run Analysis of Push and Pull Factors of Internal Migration in Italy. Estimation of a Gravity Model with Human Capital Using Homogeneous and Heterogeneous Approaches", *Papers in Regional Science,* 96(3): 571-602.

62. Poot, J., Alimi, O., Cameron, M.P., and Maré, D.C., 2016. "The Gravity Model of Migration: The Successful Comeback of an Ageing Superstar in Regional Science", *Journal of Regional Research Investigaciones Regionales*, 36: 63-86.

63. Pu, Y., Han, X., Chi, G., Wang, Y., Ge, Y., and Kong, F., 2019. "The Impact of Spatial Spillovers on Interprovincial Migration in China, 2005–10", *Regional Studies,* 53(8): 1125-1136.

64. Ramos, R., 2016. "Gravity Models: A Tool for Migration Analysis", *IZA World of Labor*, 2016: 239.

65. Ravenstein, E.G., 1885. "The Laws of Migration", *Journal of the Statistical Society of London*, 48(2): 167-235.

66. Rincke, J., 2010. "A Commuting-Based Refinement of the Contiguity Matrix for Spatial Models, and an Application to Local Police Expenditures", *Regional Science and Urban Economics*, 40(4): 324-330.

67. Rindfuss, R.R., 1991. "The Young Adult Years: Diversity, Structural Change, and Fertility," *Demography*, 28(4): 493-512.

68. Rios, V., Pascual, P., and Cabases, F., 2017. "What Drives Local Government Spending in Spain? A Dynamic Spatial Panel Approach", *Spatial Economic Analysis*, 12(2-3): 230-250.

69. Shen, J. and Wang, G., 2012. "Estimating the Contributions of Migration Factors to Interprovincial Migration in China 1995–2000", *Annals of GIS*, 18(4): 257-266.

70. Shi, K. and Wang, J., 2024. "The Influence and Spatial Effects of High-speed Railway Construction on uRban Industrial Upgrading: Based on an Industrial Transfer Perspective", *Socio-Economic Planning Sciences*, 93: 101886.

71. Tinbergen, J., 1962. *Shaping the World Economy; Suggestions for an International Economic Policy,* New York: The Twentieth Century Fund.

72. Wajdi, N., Mulder, C.H., and Adioetomo, S.M. 2017. "Inter-regional Migration in Indonesia: A Micro Approach", *Journal of Population Research*, 34: 253-277.

73. Winters, J.V., 2011. "Human Capital and Population Growth in Nonmetropolitan US Counties: The Importance of College Student Migration", *Economic Development Quarterly*, 25(4): 353-365.

74. Yoon, K.S., 2015. "An Analysis of Migration Characteristics in Dong-nam Economic Region and Its Implication for Regional Development Policy", *Journal of the Korean Regional Development Association*, 27(2): 1-16.

75. Yu, J., De Jong, R., and Lee, L.F., 2008. "Quasi-maximum Likelihood Estimators for Spatial Dynamic Panel Data with Fixed Effects when Both n and T Are Large", *Journal of Econometrics*, 146(1): 118-134.

76. Zhu, P., Li, J., and Hou, Y., 2022. "Applying a Population Flow-Based Spatial Weight Matrix in Spatial Econometric Models: Conceptual Framework and Application to COVID-19 Transmission Analysis", *Annals of the American Association of Geographers*, 112(8): 2266-2286.

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