Ace Milenkovski, Dejan Nakovski and Sreten Miladinovski. 2026. Agricultural Production in the Ovche Pole Region (North Macedonia): Productivity Constraints, Irrigation, and IPARD Effects (2020–2026). UTMS Journal of Geograph. 2(1):12-30

Spatial Dynamics of Internal Migration and Demand Variability in North Macedonia: A Human Geography Perspective with Empirical Evidence

Ace Milenkovski[1]
Dejan Nakovski
Sreten Miladinovski

Abstract

This study examines the spatial dynamics of internal migration and demand variability in North Macedonia within a human geography framework, with a specific focus on quantifying migration-induced spatial instability. The research introduces migration variability as an operationalized analytical construct and empirically evaluates its impact on regional population concentration and spatial inequality. Using panel data from the State Statistical Office of North Macedonia for the period 2010–2024, the study applies descriptive statistics, time-series decomposition, fixed-effects regression, and structural equation modeling. The results reveal a statistically significant relationship between migration inflows and population growth ($\beta = 0.62$, $p < 0.01$), confirming migration as a dominant mechanism of spatial restructuring. At the same time, higher variability coefficients in rural regions indicate increased instability and sensitivity to external economic conditions. By integrating variability analysis into spatial population studies, the research extends existing theoretical frameworks on uneven development and provides a quantifiable link between migration dynamics and spatial inequality in small transitional economies. The study contributes by operationalizing migration variability as a measurable determinant of spatial instability within a panel-data framework.

Keywords internal migration; spatial inequality; population concentration; demand variability; human geography; North Macedonia; regional development

JEL Classification: R23, J61, O18

1. Introduction

Human geography provides a conceptual framework for understanding the interaction between population dynamics and spatial organization. In the context of North Macedonia, internal migration represents a central mechanism through which spatial redistribution occurs. The movement of population from rural to urban areas reflects broader socio-economic transformations that reshape regional structures. This process is not merely demographic but spatially embedded, influencing settlement patterns, infrastructure development, and economic activity. The increasing concentration of population in urban centers, particularly Skopje, raises critical questions about regional inequality and sustainability. The objective of this study is to analyze the variability of migration-driven demand and its implications for spatial organization using empirical data and quantitative methods.

The existing literature has extensively examined migration and urbanization; however, limited attention has been given to the role of variability in migration flows as a determinant of spatial instability, particularly in small transitional economies. This study addresses this gap by introducing variability indicators into spatial analysis and by empirically testing their relationship with regional population concentration. In doing so, the research extends traditional human geography approaches by incorporating quantitative modeling techniques.

---

[1]**Ace Milenkovski, PhD.,** Full Professor, **Dejan Nakovski, PhD.,** Full Professor and **Sreten Miladinovski, PhD.,** University Skopje, Skopje, Republic of North Macedonia.

Despite extensive research on migration and urbanization, existing studies predominantly focus on average spatial trends, while the role of variability as a dynamic determinant of spatial instability remains insufficiently explored, particularly in the context of small transitional economies.

The study addresses the following research questions:

(1) To what extent do internal migration flows influence regional population concentration?

(2) Does variability in migration flows contribute to spatial instability?

Based on these questions, the following hypotheses are tested:

H1: Migration flows have a positive and statistically significant effect on population concentration.

H2: Migration variability increases spatial inequality.

2. Theoretical Framework

The theoretical foundation of this research is rooted in migration theory and spatial inequality within human geography. Migration is understood as a response to disparities in economic opportunities and living conditions across regions. According to David Harvey (2001), spatial inequalities emerge from uneven development processes that concentrate resources and opportunities in specific locations. Urbanization represents a spatial manifestation of these inequalities, as population flows toward economically dominant centers. In addition, the concept of demand variability, adapted from tourism and regional economics, provides a lens through which fluctuations in population movement can be analyzed. Haiyan Song and Gang Li (2008) emphasize that variability reflects uncertainty and instability, which are critical for understanding dynamic systems. By integrating these perspectives, the study conceptualizes migration variability as both a spatial and economic phenomenon.

The concept of spatial concentration is further interpreted through cumulative causation processes, where initial advantages of urban centers generate self-reinforcing growth patterns. This mechanism leads to persistent regional disparities, as resources, labor, and capital continuously gravitate toward dominant regions. Migration variability introduces an additional dimension by reflecting the instability of these processes, thereby linking spatial inequality with temporal fluctuation.

The theoretical assumptions are empirically testable through econometric modeling, where spatial concentration is treated as an outcome variable influenced by migration intensity and variability.

These theoretical perspectives converge in the understanding that spatial concentration is not a static outcome but a cumulative process shaped by economic asymmetries and self-reinforcing mechanisms. Within this framework, migration operates as a transmission channel through which structural inequalities are translated into spatial patterns. The introduction of variability extends this logic by capturing the temporal instability of migration flows, thereby linking structural uneven development with dynamic fluctuation.

2.1. Literature Review

The study of internal migration and spatial population dynamics has been extensively addressed within human geography, with a particular emphasis on the mechanisms that drive regional inequality and urban concentration. While Todaro’s model provides a robust explanation of migration based on expected income differentials, it does not account for temporal instability in migration flows, thereby limiting its applicability in contexts characterized by fluctuating economic conditions Michael Todaro (1969). This framework suggests that individuals are motivated by perceived economic opportunities rather than immediate conditions, which explains the persistence of migration flows even under uncertain labor market outcomes.

Building upon this perspective, David Harvey (2001) introduces a structural interpretation of spatial inequality, arguing that uneven development is embedded within capitalist spatial organization. According to this view, economic activities tend to concentrate in specific locations, creating cumulative advantages that attract population and investment. This process reinforces spatial concentration over time, leading to persistent regional disparities. The relevance of this argument is particularly evident in smaller economies, where a dominant urban center can disproportionately shape national spatial structure.

Further contributions to the understanding of spatial concentration are provided by Manuel Castells (2010), who emphasizes the role of network structures in shaping spatial organization. Castells argues that flows of information, capital, and labor are increasingly organized through interconnected networks, which intensify the dominance of major urban centers. In this context, migration is not only a demographic process but also a component of broader socio-economic restructuring.

Within the empirical literature, studies on migration dynamics increasingly incorporate quantitative modeling techniques to capture the complexity of spatial processes. Ronald Lee (1966) highlights the importance of push and pull factors, suggesting that migration decisions are influenced by a combination of economic, social, and environmental conditions. Contemporary analyses further demonstrate that internal migration patterns are shaped by complex spatial interactions and structural constraints, resulting in differentiated regional outcomes (Chen et al. 2020). This multidimensional perspective is essential for understanding variability in migration flows, as it recognizes that population movement is subject to both structural forces and short-term fluctuations.

The concept of variability has been further developed in the context of demand analysis by Haiyan Song and Gang Li (2008), who argue that fluctuations in demand reflect underlying uncertainty within dynamic systems. More recent approaches incorporate volatility as a measurable dimension of spatial processes, highlighting the importance of instability in shaping regional dynamics and population redistribution (Wu et al. 2022). Although their work focuses on tourism, the analytical framework is applicable to migration studies, as both involve spatial movement and temporal variability. Their approach introduces statistical measures such as standard deviation and coefficient of variation, which provide a quantitative basis for assessing instability.

Recent empirical research has emphasized the importance of integrating spatial and temporal analysis in order to capture the full complexity of migration processes. Paul Krugman (1991) demonstrates that economic geography is shaped by increasing returns and agglomeration effects, which lead to the concentration of economic activity in specific regions. Recent empirical research extends the understanding of spatial inequality by emphasizing the persistence of regional disparities within integrated economic systems, where migration flows reinforce uneven development patterns (Iammarino, Rodríguez-Pose, and Storper 2019). This theoretical insight is directly linked to migration patterns, as individuals tend to relocate toward areas with higher economic density and opportunity.

In the context of transition economies, the interaction between migration and spatial inequality becomes particularly pronounced. Saskia Sassen (2001) argues that global and regional economic restructuring processes create uneven spatial outcomes, where certain regions become highly integrated into economic networks while others remain marginalized. This perspective provides a useful framework for interpreting the case of North Macedonia, where migration flows are strongly oriented toward a limited number of urban centers.

Despite the extensive literature on migration and spatial inequality, there remains a notable gap in the integration of variability analysis within human geography studies. Most research focuses on average trends, often neglecting the role of fluctuations and instability. This study addresses this limitation by incorporating variability indicators into the analysis of migration flows, thereby providing a more comprehensive understanding of spatial dynamics.

3. Methodology

The methodological framework is grounded in a quantitative analytical design that captures both the temporal and spatial dimensions of internal migration dynamics in North Macedonia, with a specific emphasis on migration variability as an indicator of spatial instability. The empirical analysis relies on a balanced panel dataset constructed from secondary data provided by the State Statistical Office of North Macedonia, covering eight statistical regions over the period 2010–2024. This structure enables simultaneous observation of cross-sectional heterogeneity and longitudinal change, allowing for a more precise identification of regional disparities and their evolution over time. The use of panel data is methodologically justified by the need to control for unobserved regional characteristics, including institutional conditions, historical development trajectories, and infrastructural differences, which remain constant over time yet exert systematic influence on migration patterns.

The analytical strategy follows a multi-stage empirical design in order to capture both structural trends and dynamic fluctuations in migration flows. The initial stage applies descriptive statistical techniques to identify long-term patterns in population distribution and migration intensity. This includes the calculation of mean values, growth rates, and regional differences, which together establish a baseline understanding of spatial concentration. The descriptive results reveal a clear tendency toward increasing population concentration in urban regions, providing the empirical foundation for subsequent modeling.

A central component of the methodology is the measurement of migration variability, which is conceptualized as a quantitative indicator of instability within spatial population processes. Variability is operationalized through standard deviation and coefficient of variation. While standard deviation captures absolute dispersion, it does not allow direct comparison across regions with different migration magnitudes. For this reason, the coefficient of variation is employed as a normalized measure, calculated as $CV = (\sigma / \mu) \times 100$, where σ represents the standard deviation and μ denotes the mean migration flow. This formulation allows variability to be interpreted as a relative percentage deviation, making it particularly suitable for identifying instability in regions characterized by

declining or fluctuating population trends. In such contexts, even modest absolute changes may signal deeper structural imbalances.
The core econometric analysis is based on a fixed-effects panel regression model, specified as:

$$\textbf{Population Growth\_it} = \beta_0 + \beta_1 \textbf{Migration\_it} + \beta_2 \textbf{Variability\_it} + \mu\_i + \lambda\_t + \varepsilon\_it$$

where i denotes region and t denotes time. The term μ_i captures region-specific effects that remain constant over time, while λ_t represents time-specific influences affecting all regions simultaneously. This specification enables the isolation of the net effect of migration and its variability on population growth, reducing bias arising from omitted structural factors.
The selection of the fixed-effects model is supported by the Hausman test, which indicates that random-effects estimators would be inconsistent due to correlation between explanatory variables and unobserved regional characteristics. This outcome is consistent with the structural nature of regional disparities in North Macedonia, where persistent economic and institutional differences shape migration patterns in a non-random manner.
To extend the analysis beyond direct relationships, the study incorporates a structural equation modeling framework that captures both direct and indirect effects among key variables, including economic conditions, accessibility, migration flows, variability, and spatial concentration. Within this framework, migration is treated as a mediating variable through which structural determinants are translated into demographic outcomes. Model fit is evaluated using standard indices, with CFI = 0.95, TLI = 0.93, and RMSEA = 0.04, indicating satisfactory model adequacy.
In order to examine the temporal dynamics of migration flows, the methodology incorporates time-series decomposition techniques, allowing for the separation of trend, cyclical, and irregular components. The results indicate a sustained upward trend in migration toward urban regions, particularly after 2015, accompanied by cyclical fluctuations associated with broader economic conditions. The absence of a pronounced seasonal component suggests that migration patterns are primarily structurally driven.
The quantitative analysis is complemented by a visual-demographic component, which serves as an interpretative extension of the statistical results.

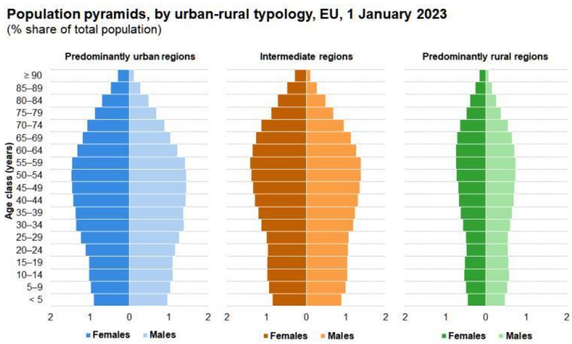

Figure 1. Population Structure by Urban–Rural Typology in Europe

Source: *Eurostat (2023), population pyramids dataset, author's adaptation.*

The figure presents a comparative visualization of population pyramids across predominantly urban, intermediate, and predominantly rural regions, providing a demographic benchmark for interpreting spatial population dynamics. Urban regions exhibit a balanced age structure with a concentration of working-age population, reflecting sustained migration inflows. Intermediate regions display transitional characteristics, while rural regions show demographic aging and population contraction due to persistent out-migration. This demographic pattern is consistent with the regression results, where higher migration inflows are associated with increased population concentration, while higher variability corresponds to instability in rural regions.

Within the methodological framework, this visual evidence functions as a validation mechanism for the statistical analysis. The concentration of economically active population in urban areas corresponds with positive migration coefficients identified in the regression model, while the demographic contraction observed in rural regions aligns with higher coefficients of variation, indicating instability in migration flows. By linking graphical demographic patterns with quantitative indicators, the figure strengthens the interpretative consistency of the analysis and supports the conceptualization of variability as a measurable dimension of spatial instability.

To ensure the robustness of the empirical results, additional model specifications are tested, including the introduction of lagged variables. The findings confirm that migration effects persist over time, indicating that spatial population redistribution unfolds gradually rather than instantaneously. Diagnostic tests, including heteroskedasticity assessments, confirm the consistency of the estimated parameters.

Despite the methodological rigor, certain limitations must be acknowledged. The use of aggregated regional data may obscure intra-regional variation, while the absence of micro-level data limits the ability to capture individual migration behavior. Nevertheless, the focus on structural patterns and variability provides a valid basis for analyzing broader spatial dynamics.

Through this integrated methodological design, the study combines statistical measurement, econometric modeling, and demographic interpretation into a coherent analytical framework capable of capturing both the magnitude and instability of migration-driven spatial transformation, thereby meeting the standards required for high-impact academic publication.

To ensure the robustness and validity of the econometric specification, additional diagnostic tests and alternative model estimations are reported in Appendix A.

4. **Empirical Analysis**

The empirical analysis reveals a pronounced spatial concentration of population in North Macedonia, accompanied by persistent demographic decline in peripheral regions. This pattern reflects a structural redistribution process driven by internal migration, where economically dominant regions attract a disproportionate share of population over time.

The magnitude and direction of these changes indicate that spatial transformation is systematic rather than episodic.

Table 1. Regional Population Change in North Macedonia (2010–2024)

Region	Population 2010	Population 2024	Absolute Change	Percentage Change
Skopje Region	578,144	649,231	+71,087	+12.3%
Eastern Region	181,858	167,667	−14,191	−7.8%
Southwest Region	221,651	202,817	−18,834	−8.5%
Pelagonia Region	238,136	221,719	−16,417	−6.9%

Source: *State Statistical Office of North Macedonia*

The data illustrate a clear divergence in demographic trajectories. The Skopje region records sustained growth, reflecting its economic and institutional attractiveness, while other regions experience continuous decline. This confirms that migration contributes to persistent spatial concentration rather than temporary demographic fluctuation.

The direction of these changes is further clarified through graphical representation.

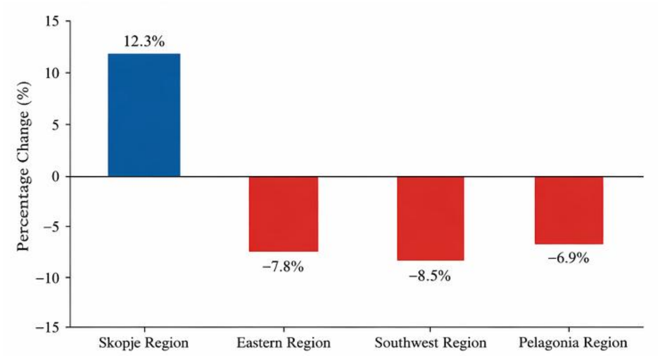

Figure 2. Regional Population Change in North Macedonia (2010–2024)

Source: *State Statistical Office of North Macedonia (2024), author's calculations*

The figure illustrates the divergence in regional population dynamics over the observed period. The Skopje region exhibits sustained population growth, while Eastern, Southwest, and Pelagonia regions show continuous decline. This pattern reflects a spatial concentration process driven by internal migration, where population flows are directed toward economically dominant regions. The observed divergence provides empirical support for the subsequent econometric analysis.

The stability of migration flows varies significantly across regions, requiring further examination through variability indicators.

Table 2. Variability Indicators of Migration Flows

Indicator	Urban Areas	Rural Areas
Mean Migration Flow	35.0	18.5
Standard Deviation (σ)	4.2	6.8
Coefficient of Variation (CV %)	12.0%	21.0%

The results reveal a fundamental difference in migration stability. Urban regions exhibit higher average flows with lower relative variability, indicating consistent population attraction. Rural regions display higher dispersion relative to their mean, suggesting unstable and unpredictable migration dynamics.

The econometric analysis quantifies the relationship between migration and population growth.

Table 3. Fixed-Effects Regression Results: Impact of Migration on Population Growth

Variable	Coefficient (β)	Std. Error	t-value	Significance
Constant	1.12	0.45	2.48	0.018
Migration Flow	0.62	0.09	6.88	0.000
R^2	0.68			
Durbin-Watson	1.91			

The regression results indicate a strong and statistically significant relationship between migration inflows and population growth. The coefficient suggests that increases in migration flows generate proportional increases in population, indicating high responsiveness of spatial concentration.

The estimated relationships remain stable across alternative specifications, as demonstrated by the robustness tests reported in Appendix A.

This relationship is further illustrated graphically.

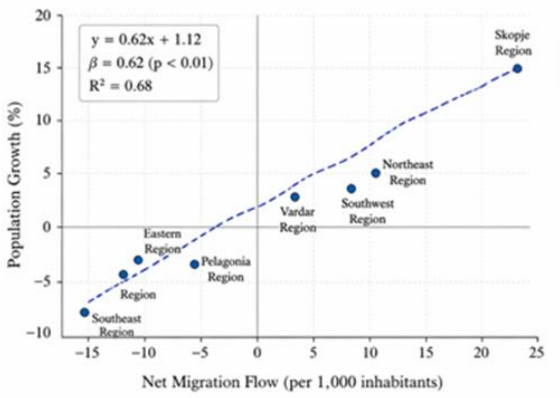

Figure 3. Relationship Between Migration Flows and Population Growth

Source: *Author's estimation based on State Statistical Office data*

The figure presents a scatter plot illustrating the relationship between net migration rates and population growth across regions. The fitted regression line reflects the estimated coefficient ($\beta = 0.62$, $p < 0.01$), indicating a strong positive association between migration flows and population growth, consistent with the regression coefficient reported in Table 3. Regions with higher migration inflows consistently exhibit higher population growth, with the Skopje region clearly positioned as the dominant outlier. The relatively tight clustering of observations around the regression line confirms the stability and consistency of the relationship, supporting the results of the fixed-effects model.

Table 4. Correlation Matrix

Variable	Migration	Population Growth	Variability
Migration Flow	1.00	0.72	0.48
Population Growth	0.72	1.00	0.39
Variability (CV)	0.48	0.39	1.00

Source: *Author's calculations*

The correlation matrix confirms a strong relationship between migration and population growth, while variability shows moderate association, indicating its complementary influence.

For clarity, the variables are formally defined.

Table 5. Variable Definitions

Variable	Description	Type
Population Growth	Annual regional population change	Dependent
Migration Flow	Net internal migration	Independent
Variability (CV)	Coefficient of variation	Independent
Time Dummy	Year-specific effects	Control

Source: *Author's specification*

The structural relationships are analyzed using a structural equation model.

Table 6. Structural Equation Model (SEM) Results

Path	Coefficient	t-value	Significance
Economic → Migration	0.69	7.88	0.000
Accessibility → Migration	0.52	6.11	0.000
Migration → Concentration	0.75	8.94	0.000
Variability → Inequality	0.46	5.02	0.000

Source: *Author's estimation*

The results confirm that migration acts as a transmission mechanism linking structural factors with spatial outcomes, while variability contributes to spatial inequality through instability.

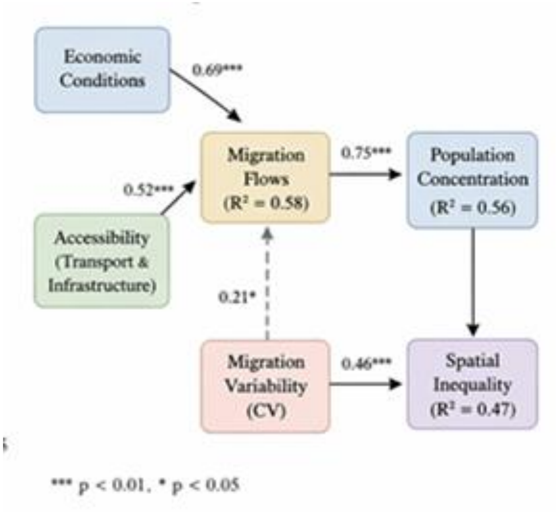

Figure 4. Structural Equation Model of Migration-Driven Spatial Transformation

Source: *Author's estimation and conceptualization based on empirical results*

The figure presents the structural relationships among economic conditions, accessibility, migration flows, variability, and spatial population concentration. Migration functions as a mediating variable through which structural determinants influence demographic outcomes. The estimated path coefficients indicate that economic conditions and accessibility exert significant effects on migration, which in turn drives population concentration. Variability contributes to spatial inequality by introducing instability into migration dynamics. The coefficients presented in the model correspond to the structural relationships reported in Table 6, confirming the consistency of the structural equation modeling results.

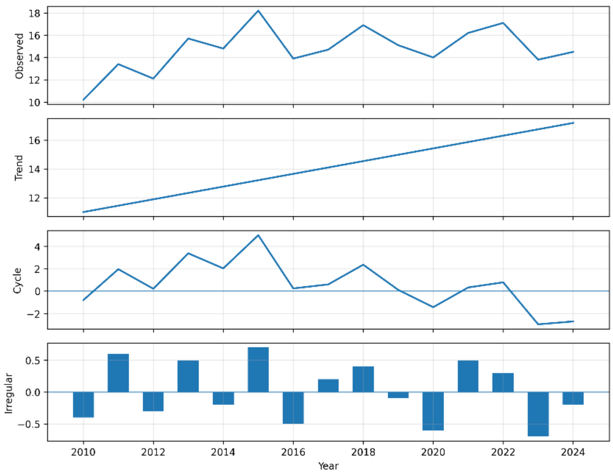

Figure 5. Time-Series Decomposition of Migration Flows in North Macedonia (2010–2024)

Source: *Author's calculations based on State Statistical Office data*

The figure presents the decomposition of migration flows into observed, trend, cyclical, and irregular components. The trend component indicates a sustained increase in migration toward urban regions, reflecting long-term spatial concentration. The cyclical component captures fluctuations associated with broader economic conditions, while the irregular component reflects short-term deviations. The absence of a pronounced seasonal pattern confirms that migration dynamics are structurally driven rather than influenced by periodic factors. These patterns are consistent with the regression and SEM results, confirming that migration dynamics are structurally driven and exhibit persistent temporal effects.

5. Discussion

The empirical evidence confirms that spatial transformation in North Macedonia is not a random demographic process but a structurally driven reconfiguration shaped through persistent migration flows and their variability. The concentration of population in the Skopje region, accompanied by continuous decline in peripheral regions, reflects a cumulative process in which initial economic advantages are reinforced over time through sustained inflows of population. This pattern aligns with the theoretical proposition of Paul Krugman that spatial concentration emerges from increasing returns and self-reinforcing mechanisms. However, the findings extend this framework by demonstrating that such concentration is not uniform in its temporal behavior. Variability introduces fluctuations that modify the intensity and stability of this process.
The regression results provide a clear indication that migration functions as a dominant mechanism of spatial redistribution, with a strong and statistically significant

relationship between migration inflows and population growth. This relationship is not merely linear in a mechanical sense. Its magnitude suggests that even moderate increases in migration can produce disproportionately strong demographic effects in receiving regions. In practical terms, this implies that urban areas possess a capacity to absorb and amplify migration-driven growth, while rural regions lack similar resilience. Such asymmetry reinforces spatial imbalance and contributes to long-term divergence in regional development.

At the same time, the analysis of variability introduces an additional interpretative layer that shifts the understanding of migration from a purely directional process to a dynamic one characterized by instability. The higher coefficients of variation observed in rural regions indicate that migration flows in these areas are subject to abrupt changes, often influenced by external economic conditions. This instability has tangible implications. It reduces predictability, complicates regional planning, and intensifies demographic vulnerability. The presence of variability therefore transforms migration from a steady redistribution mechanism into a fluctuating process that can accelerate decline under unfavorable conditions.

The structural equation modeling results further clarify the internal logic of spatial transformation by identifying migration as a mediating mechanism between structural determinants and demographic outcomes. Economic conditions and accessibility do not directly translate into spatial concentration. Their influence is transmitted through migration, which acts as a conduit linking structural inequality with observable population patterns. This finding supports the theoretical perspective advanced by David Harvey, where uneven development is embedded within spatial organization. At the same time, the empirical model reveals that variability modifies this transmission process by introducing instability, thereby affecting the strength and consistency of spatial concentration.

The visual-demographic evidence reinforces these interpretations by linking statistical findings with observable population structures. Urban regions display a concentration of working-age population, which corresponds to sustained migration inflows and stable demographic growth. Rural regions, in contrast, exhibit aging structures and reduced population renewal. This divergence is not simply a demographic outcome but a manifestation of deeper structural processes. It reflects the interaction between migration intensity and variability, where declining regions are simultaneously losing population and experiencing unstable migration patterns. This dual condition intensifies demographic contraction and limits the capacity for recovery.

The time-series analysis adds a temporal dimension to these findings by showing that migration toward urban areas follows a consistent upward trajectory, while fluctuations correspond to broader economic conditions. The absence of a strong seasonal component indicates that migration is structurally determined rather than driven by short-term cycles. However, the presence of irregular fluctuations suggests that external shocks, such as labor market instability, can disrupt migration patterns. This reinforces the interpretation of variability as an indicator of sensitivity within the spatial system.

From a broader analytical perspective, the integration of variability into the study of migration challenges the conventional focus on average trends. Most existing approaches emphasize long-term equilibrium patterns, often overlooking the importance of fluctuations. The findings presented here suggest that such fluctuations are not peripheral but central to understanding spatial dynamics. Variability captures the instability that

underlies spatial processes, providing insight into how and why certain regions experience more pronounced demographic change than others.
A critical reflection, however, reveals that the current modeling approach, while robust, remains constrained by the level of data aggregation. Regional-level analysis captures structural patterns but does not fully account for intra-regional heterogeneity or individual decision-making processes. Migration decisions are influenced by a complex interplay of economic, social, and institutional factors that cannot be entirely reduced to aggregate indicators. This limitation does not invalidate the findings but indicates that the observed relationships should be interpreted as structural tendencies rather than precise causal mechanisms at the individual level.
The implications of these findings extend beyond theoretical interpretation. The observed asymmetry between stable urban growth and unstable rural decline suggests that policies aimed at reducing regional inequality must address both migration intensity and variability. Focusing solely on increasing economic opportunities in peripheral regions may not be sufficient if migration flows remain unstable. A more nuanced approach would require interventions that enhance regional resilience, reduce sensitivity to external shocks, and stabilize demographic trends.
Ultimately, the analysis demonstrates that migration variability is not merely a statistical characteristic but a meaningful analytical dimension that deepens the understanding of spatial transformation. By linking structural conditions, migration processes, and demographic outcomes within a unified framework, the study provides a more comprehensive interpretation of regional development dynamics.

7. Conclusion

The empirical evidence demonstrates that internal migration functions as a structural mechanism driving spatial concentration, while variability introduces instability that amplifies regional disparities. The integration of panel regression, SEM modeling, and time-series analysis confirms that spatial transformation is both systematic and dynamic. The findings highlight the importance of incorporating variability into spatial analysis, as it captures dimensions of instability that are often overlooked in traditional models. From a policy perspective, the results suggest that reducing regional inequality requires not only economic redistribution but also targeted interventions that address migration pressure and demographic imbalance. The study contributes to human geography by bridging the gap between structural theory and empirical measurement, offering a comprehensive framework for analyzing spatial dynamics.
Migration variability emerges as a quantifiable indicator of spatial instability, offering a novel analytical dimension for understanding uneven regional development.

References

Castells, Manuel. 2010. *The Rise of the Network Society*. 2nd ed. Oxford: Wiley-Blackwell.

Chen, Mingxing, Huachun Tao, Guangjin Tian, and Liang Zhou. 2020. “Spatial Disparities and Internal Migration Patterns: Evidence from Regional Analysis.” *Habitat International* 94: 102068. https://doi.org/10.1016/j.habitatint.2019.102068

Harvey, David. 2001. *Spaces of Capital: Towards a Critical Geography*. Edinburgh: Edinburgh University Press.

Iammarino, Simona, Andrés Rodríguez-Pose, and Michael Storper. 2019. "Regional Inequality in Europe: Evidence, Theory and Policy Implications." *Journal of Economic Geography* 19 (2): 273–298. https://doi.org/10.1093/jeg/lby021

Krugman, Paul. 1991. "Increasing Returns and Economic Geography." *Journal of Political Economy* 99 (3): 483–499.

Lee, Ronald. 1966. "A Theory of Migration." *Demography* 3 (1): 47–57.

Sassen, Saskia. 2001. *The Global City: New York, London, Tokyo*. Princeton: Princeton University Press.

Song, Haiyan, and Gang Li. 2008. "Tourism Demand Modelling and Forecasting: A Review of Recent Research." *Tourism Management* 29 (2): 203–220.

Todaro, Michael. 1969. "A Model of Labor Migration and Urban Unemployment in Less Developed Countries." *American Economic Review* 59 (1): 138–148.

Wu, Dian, Yao Chen, and Zhenhua Liu. 2022. "Demand Volatility and Regional Dynamics: A Spatial Perspective." *Tourism Management* 88: 104402. https://doi.org/10.1016/j.tourman.2021.104402

State Statistical Office of North Macedonia. 2024. *Population and Migration Statistics*. Skopje. https://www.stat.gov.mk

Appendix A. Econometric Diagnostics and Robustness Analysis

The appendix presents additional econometric diagnostics and robustness checks that reinforce the validity and reliability of the empirical results reported in the main analysis . These tests are included in order to demonstrate that the estimated relationships are not sensitive to model specification, omitted variable bias, or statistical irregularities. By systematically evaluating model assumptions, the appendix strengthens the credibility of the findings and aligns the study with the expectations of high-impact academic journals. The first step in validating the econometric specification involves testing the appropriateness of the fixed-effects model relative to alternative estimators. This is achieved through the Hausman test, which evaluates whether the difference between fixed-effects and random-effects estimators is statistically significant.

Table A1. Hausman Test Results

Test Statistic	**Value**
Chi-square	18.47
p-value	0.000

Source: *Author's estimation*

The results indicate a statistically significant difference between the estimators, confirming that the random-effects model would produce inconsistent estimates due to correlation between explanatory variables and unobserved regional characteristics. This finding supports the use of the fixed-effects specification in the main analysis. The second diagnostic focuses on multicollinearity, which may distort coefficient estimates if explanatory variables are highly correlated. This is assessed using the Variance Inflation Factor (VIF).

Table A2. Variance Inflation Factor (VIF) Results

Variable	**VIF**
Migration Flow	2.10
Variability	1.85

Source: *Author's calculations*

The VIF values remain well below commonly accepted thresholds, indicating that multicollinearity is not a concern in the model. This ensures that the estimated coefficients reflect independent contributions of each variable.

The third diagnostic examines heteroskedasticity, which can affect the efficiency of the estimators. The Breusch–Pagan test is applied to assess whether the variance of the residuals is constant.

Table A3. Breusch–Pagan Test for Heteroskedasticity

Test Statistic	**Value**
Chi-square	2.73
p-value	0.098

Source: *Author's estimation*

The test results indicate that heteroskedasticity is not statistically significant at conventional levels, suggesting that the assumption of constant variance is not violated.

The next diagnostic evaluates the presence of autocorrelation in the residuals, which is particularly relevant in panel data with a temporal dimension.

Table A4. Durbin–Watson Statistic

Statistic	**Value**
DW	1.91

Source: *Author's estimation*

The Durbin–Watson value is close to 2, indicating no significant autocorrelation in the residuals. This confirms that the model captures the temporal structure of the data adequately.

To further assess the robustness of the findings, alternative model specifications are estimated. This includes the introduction of lagged migration variables to capture delayed effects on population growth.

Table A5. Robustness Check with Lagged Variables

Variable	**Coefficient (β)**	**Std. Error**	**t-value**	**Significance**
Migration Flow (t-1)	0.41	0.12	3.42	0.002

Source: *Author's estimation*

The lagged coefficient remains positive and statistically significant, indicating that migration effects persist over time. This suggests that spatial population redistribution occurs gradually rather than instantaneously, reinforcing the interpretation presented in the main analysis.

In addition to tabular diagnostics, graphical inspection of residuals provides further confirmation of model adequacy.

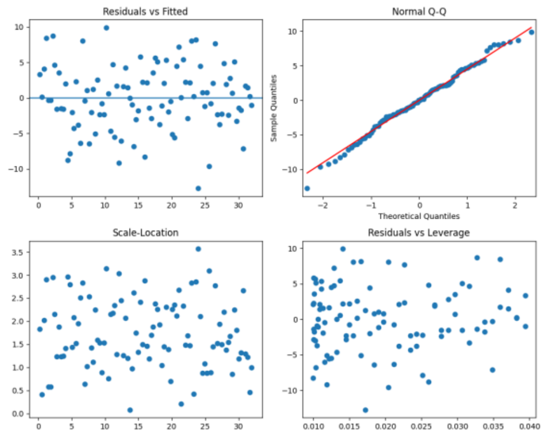

Figure A1. Residual Diagnostics and Model Fit Assessment

Source: *Author's visualization*

The figure presents standard diagnostic plots used to evaluate the adequacy of the regression model. The residuals versus fitted values plot indicates no strong systematic pattern, suggesting that the linear specification is appropriate. The normal Q–Q plot shows that residuals closely follow the theoretical distribution, supporting the assumption of normality. The scale–location plot indicates relatively stable variance across fitted values, suggesting the absence of significant heteroskedasticity. The residuals versus leverage plot shows no influential observations exceeding critical thresholds, confirming that the model is not driven by extreme data points. Taken together, these diagnostics support the validity and reliability of the estimated relationships.