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REGIONAL INCOME DYNAMICS IN TÜRKİYE: CONVERGENCE, SPATIAL SPILLOVERS, AND STRUCTURAL DETERMINANTS*

TÜRKİYE'DE BÖLGESEL GELİR DİNAMİKLERİ: YAKINSAMA, MEKANSAL YAYILMA ETKİLERİ VE YAPISAL BELİRLEYİCİLER

Nilüfer KAYA KANLI [1]
ORCID:0000-0001-9049-3862

Abstract

This study examines income convergence across Turkish provinces over the period 2004-2023 by combining traditional convergence analysis with spatial econometric methods. Both unconditional and conditional convergence models are estimated using provincial data. To account for structural heterogeneity across regions, the empirical framework incorporates net migration rates, trade openness, educational attainment, and digital infrastructure measured by per-capita fiber-optic cable length. The results show that income convergence slowed considerably over time and varied across sub-periods. The estimated speed of convergence declined from 1.77% per year during 2004-2013 to 0.76% during 2013-2023, while convergence is not statistically significant for 2020-2023. Moran's I values remain high (0.64-0.69) throughout the sample period, indicating persistent positive spatial dependence among provinces. Spatial panel models further reveal significant regional spillovers, with the spatial autoregressive coefficient ranging from 0.295 to 0.776 across estimation periods. Overall, the findings suggest that regional income dynamics in Türkiye are shaped by both structural factors and spatial interactions, highlighting the need for region-specific and spatially coordinated development policies.

Keywords: Unconditional Convergence, Conditional Convergence, Regional Inequality, Spatial Econometrics

Öz

Bu çalışma, 2004-2023 döneminde Türkiye'de iller arasındaki gelir yakınsamasını geleneksel yakınsama analizi ile mekansal ekonometri yöntemlerini birleştirerek incelemektedir. Analizde il düzeyindeki veriler kullanılarak hem koşulsuz hem de koşullu yakınsama modelleri tahmin edilmiştir. Bölgeler arasındaki yapısal farklılıkları dikkate almak amacıyla ampirik çerçeveye net göç oranı, ticari açıklık, eğitim düzeyi ve kişi başına düşen fiber optik kablo uzunluğu ile ölçülen dijital altyapı değişkenleri dahil edilmiştir. Bulgular, gelir yakınsamasının zaman içinde belirgin biçimde yavaşladığını ve alt dönemler arasında farklılaştığını göstermektedir. Tahmin edilen yakınsama hızı 2004-2013 döneminde yıllık %1,77 iken, 2013-2023 döneminde %0,76'ya gerilemiş; 2020-2023 dönemi için ise yakınsama anlamlı değildir. Moran's I değerleri analiz dönemi boyunca yüksek düzeyde (0,64-0,69) seyrederek iller arasında kalıcı pozitif mekansal bağımlılığın varlığını göstermektedir. Mekansal panel modelleri de mekansal otoregresif katsayının tahmin dönemlerine göre 0,295 ile 0,776 arasında değiştiğini ortaya koyarak anlamlı bölgesel yayılma etkilerini doğrulamaktadır. Genel olarak bulgular, Türkiye'de bölgesel gelir dinamiklerinin hem yapısal faktörler hem de mekansal etkileşimler tarafından şekillendiğini ortaya koymakta ve bölgelere özgü, mekansal açıdan koordineli kalkınma politikalarına duyulan ihtiyacı vurgulamaktadır.

Anahtar Kelimeler: Koşulsuz Yakınsama, Koşullu Yakınsama, Bölgesel Eşitsizlik, Mekansal Ekonometri

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[1] Dr., İzmir Ekonomi Üniversitesi, nilukaya@gmail.com

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Introduction

Regional income differences have long been one of the most persistent features of economic development. In many countries, disparities across regions remain large even during periods of sustained national growth, raising questions about whether market forces alone are sufficient to promote balanced development. The concept of income convergence provides a natural framework for addressing these questions, as it focuses on whether poorer regions tend to grow faster than richer ones over time. From a policy perspective, convergence is closely linked to regional cohesion and the design of effective regional development policies.

Türkiye represents a particularly relevant case for examining regional income convergence. Despite several decades of structural transformation and integration into global markets, economic activity remains unevenly distributed across provinces. Western and coastal regions continue to dominate in terms of income and industrial capacity, while eastern and southeastern provinces lag behind. These differences reflect a combination of historical development patterns, variations in educational attainment, differences in access to infrastructure, and the geographic concentration of economic activity. Migration towards large metropolitan areas has further shaped regional income patterns, often reinforcing existing disparities rather than eliminating them. At the same time, Türkiye has experienced repeated macroeconomic disruptions, which may have altered regional growth patterns in ways that are not fully captured by long-run averages.

Empirical research on income convergence has expanded substantially since the early contributions of the neoclassical growth literature. Initial studies relied on relatively simple cross-sectional regressions, testing whether growth rates were negatively related to initial income levels. Over time, it became clear that regions differ systematically in their structural characteristics, leading to the widespread adoption of conditional convergence frameworks. These models allow growth paths to depend on factors such as human capital, demographic structure, openness, and infrastructure. More recent contributions have emphasized that regional economies are not independent units, but are linked through spatial interactions. Income levels and growth rates often display strong geographic clustering, suggesting that developments in one region may affect neighboring regions through spillovers or shared shocks.

In the Turkish context, early empirical studies documented the persistence of regional dualism, particularly between industrialized western provinces and less developed eastern regions. As provincial data improved, later studies adopted panel data techniques to control for unobserved heterogeneity and to distinguish between absolute and conditional convergence. These analyses generally found evidence of slow convergence, with estimated speeds varying across periods and specifications. More recent research has drawn attention to the importance of spatial dependence, showing that provincial income levels in Türkiye are spatially correlated. This finding has important implications, as ignoring spatial interactions can bias estimates of convergence and obscure the role of regional spillovers.

Despite this extensive literature, several aspects of regional income convergence in Türkiye remain insufficiently explored. First, many existing studies focus on long sample periods, which may conceal important changes in convergence dynamics associated with policy shifts or major economic events. Second, while spatial dependence is increasingly acknowledged, relatively few studies combine convergence analysis with spatial panel models that allow for both province-specific and time-specific effects. Third, the post-2020 period, characterized by heightened volatility and the economic consequences of the COVID-19 pandemic, has not yet been systematically incorporated into provincial convergence analyses. More broadly, the 2004-2023 period encompasses several structural changes (including the global financial crisis, rapid digitalization, the COVID-19 pandemic, and subsequent macroeconomic instability) that may have affected convergence dynamics.

The role of digital infrastructure has received limited attention despite its growing importance for

regional competitiveness. By facilitating knowledge diffusion, reducing communication and transaction costs, improving firms' productivity, and expanding access to markets and public services, digital infrastructure may influence both regional income levels and the speed of convergence. Given its rapid expansion across Turkish provinces over the last decade, incorporating this dimension provides a more comprehensive explanation of regional income disparities and represents an important contribution to the literature.

The primary objective of this study is to examine regional income convergence across Turkish provinces during the period 2004-2023. Specifically, the study aims to (i) investigate whether absolute and conditional income convergence exists across provinces, (ii) assess the roles of migration, trade openness, educational attainment, and digital infrastructure in regional income convergence, and (iii) examine whether spatial dependence and regional spillover effects influence the convergence process.

The contribution of this study is threefold. First, it provides an updated assessment of provincial income convergence in Türkiye, extending the analysis through 2023, a period that includes significant economic disruptions. Second, by adopting a sub-period approach, the study highlights how convergence dynamics have evolved over time rather than treating them as stable long-run phenomena. Third, by combining conditional convergence analysis with spatial panel econometric methods and explicitly incorporating digital infrastructure, the study provides new evidence on the spatial and structural drivers of regional income disparities in Türkiye.

Regional income disparities have long been a central concern of regional development policy in Türkiye. Development plans and development agencies have sought to reduce interregional disparities by improving infrastructure, strengthening human capital, promoting innovation, and enhancing regional competitiveness. Evaluating whether provincial incomes are converging and identifying the role of spatial interactions therefore provides evidence for assessing these policies and designing more spatially coordinated regional development strategies. The findings of this study are intended to contribute to this policy discussion by providing updated evidence on the evolution of regional income disparities in Türkiye.

1. Literature Review

Income convergence has been a major research topic in regional economics literature. According to the neoclassical growth model introduced by Solow (1956), economies with lower initial income levels have the capacity to grow faster than wealthier ones. Subsequently, Barro and Sala-i-Martin (1992) and Barro (1996) formalized an empirically testable framework for convergence, which has been used in many empirical studies.

In the Turkish context, the income convergence literature has developed extensively since the 1990s. Over the past three decades, studies have advanced both methodologically and in their understanding of regional convergence dynamics. Descriptive analysis and cross-sectional regressions were used in the first wave of studies in the early 1990s. Tansel and Güngör (1999) estimated a regression of average growth on initial income levels by using cross-sectional data on provincial GDP per capita between 1975 and 1995. They found evidence of weak absolute convergence. Filiztekin (1998) conducted the first comprehensive province-level analysis for the period 1975 and 1995. He employed both OLS cross-sections and fixed effects panel models, and found absolute convergence ranging between 1% and 2%.

During the 2000s, with the availability of regional data, researchers increasingly examined not only absolute convergence but also conditional convergence. Researchers also began incorporating spatial interdependence into convergence analyses, allowing them to capture regional spillover effects more effectively.

Gezici and Hewings (2004) used data for the 1980-1997 period, and employed Moran's *I* statistic to detect spatial autocorrelation and the Local Indicators of

Spatial Association (LISA) to identify high- and low-income clusters. According to their results, there was strong positive spatial autocorrelation in all periods, and provinces with similar income levels tended to be geographically clustered. Yıldırım and Öcal (2006) analyzed provincial data covering the 1979-2001 period and estimated both Spatial Autoregressive (SAR) and Spatial Error Models (SEM) to account for possible spatial dependence in income growth. Their results indicate that incorporating spatially lagged income variables lowered the estimated speed of β-convergence while improving the overall fit of the model. Güçlü (2010) analyzed per capita income convergence across the provinces of Türkiye for the period 1990-2000. The results of regressions disregarding spatial autocorrelation indicate the absence of convergence while the results of the spatial regressions provide empirical evidence of both absolute and conditional convergence across the provinces.

Karahasan (2015) investigated the path of the regional inequalities for the post 2001 period and showed that out of the 26 sub-regions, 5 of the NUTS II regions in eastern Türkiye moved to a group of regions with lower wage income during the 2003-2008 period. Karahasan (2017) studied pre- and post-2001 periods and concluded that convergence is slower during post 2001 period although regional disparities exist in Türkiye regardless of the investigated time interval.

With the improvement in methodologies, studies started implementing alternative frameworks such as club convergence and nonlinear dynamics. Recent studies have further demonstrated that conclusions regarding regional convergence in Türkiye depend considerably on the period, spatial unit, sectoral structure, and empirical methodology employed. Using data for the 26 NUTS-2 regions over 2004-2011, Doğan and Kındap (2019) found evidence of absolute convergence and strong spatial autocorrelation. They also showed that regional inequality declined during the 2008-2009 recession but increased during periods of economic expansion, suggesting that convergence was countercyclical. Çınar and Sağdıç (2020), applying a spatial panel approach with Driscoll-Kraay estimation to 81 provinces for 2008-2018, reported limited convergence in the agricultural sector and emphasized that migration between agricultural and non-agricultural activities affected sectoral convergence, whereas public expenditure had no statistically significant effect. Elmalı et al. (2021) compared conventionally measured provincial GDP with income estimates based on night-time lights for 1992-2017. Their spatial Durbin, spatial lag, and spatial error models produced evidence of both absolute and conditional convergence across provinces under both datasets, reinforcing the importance of neighbouring regional dynamics.

Adopting an income-distribution perspective, Akkay (2022) found that relatively high-income provinces converged strongly toward the national average, while relatively low-income provinces diverged from it. The study also showed that provincial income disparities narrowed during economic slowdowns but worsened during high-growth periods. Aksoy et al. (2019), using the Phillips and Sul club-convergence procedure for 81 NUTS-III regions, found no evidence of either absolute or conditional convergence over 1987-2017. Instead, they identified five convergence clubs for 1987-2001 and six clubs for 2004-2017. The geographical distribution of these clubs revealed a persistent separation between eastern and western Türkiye, while initial per capita income, human capital, and total credit were identified as the main determinants of club membership. Ursavaş and Mendez (2023) suggested six convergence clubs for Turkish provinces and showed that the provinces do not converge to a common long-run equilibrium by using a nonlinear dynamic factor model.

More recently, Bozdoğan (2024) found evidence of σ-convergence but no stochastic convergence at the aggregate panel level, with heterogeneous outcomes across individual provinces. Taken together, these findings suggest that regional convergence in Türkiye is neither uniform nor stable over time, but is characterized by spatial clustering, structural heterogeneity, business-cycle sensitivity, and the formation of distinct convergence clubs.

The international convergence literature has similarly moved beyond models that treat regions as

independent observations. Rey and Montouri (1999) provided an early spatial econometric analysis of income convergence among US states. They found strong global and local spatial autocorrelation and showed that the standard convergence regression was misspecified when spatial error dependence was ignored. Their study established that shocks originating in one region may affect neighbouring regions and thereby alter estimated convergence dynamics.

For European regions, Le Gallo and Ertur (2003) documented persistent global and local spatial autocorrelation in regional GDP per capita. Their analysis identified geographically concentrated high and low income clusters, indicating that European regional disparities had both spatial and temporal dimensions. Ramajo et al. (2008) subsequently estimated regional convergence for 163 European Union regions while accounting jointly for spatial autocorrelation and spatial heterogeneity. They found different convergence speeds between cohesion-country regions and other EU regions, as well as evidence of distinct spatial convergence clubs. These results demonstrate that spatial dependence can coexist with heterogeneous steady states and region-specific convergence processes.

Spatial panel models provide a particularly appropriate framework when regional units are observed repeatedly over time. Lim and Kim (2015), for example, used spatial and time fixed effects panel models to examine convergence across 177 economic areas. Their estimates showed that the magnitude of the convergence coefficient changed depending on whether spatial dependence was represented through a spatially lagged dependent variable or a spatial error process. This finding illustrates that the estimated speed of convergence may be sensitive to the form of spatial interaction imposed by the empirical model.

The broader international evidence also shows that spatial dependence does not necessarily imply complete convergence. Lim (2016) identified separate core and peripheral spatial regimes among US economic areas and found that convergence patterns differed significantly between them. Similarly, Peiro-Palomino et al. (2023), examining Colombian departments, found that spatial context influenced long-run regional income distribution, while geographical polarization and core-periphery differences remained persistent. These studies emphasize that neighbouring effects may shape the convergence path without eliminating structural regional inequality.

Overall, the international literature demonstrates that omitting spatial dependence can produce incomplete or misleading conclusions about regional convergence. Spatial autoregressive models capture interactions in which income outcomes in one region are related to outcomes in neighbouring regions, whereas spatial error models capture geographically correlated omitted factors and common shocks. The comparison of these specifications is therefore useful for identifying whether observed spatial dependence primarily reflects substantive regional interaction or spatially correlated unobserved influences.

Although the literature has considerably advanced our understanding of regional convergence in Türkiye, relatively few studies simultaneously examine recent convergence dynamics, structural determinants including digital infrastructure, and spatial dependence within a unified empirical framework. The present study addresses this gap by combining conventional convergence analysis with spatial panel econometric models for the period 2004-2023.

2. Data and Methodology

This study investigates income convergence across the provinces of Türkiye. In the first part of the analysis, absolute convergence is analyzed for the 2004-2023 period by using real per capita GDP in U.S. dollars. These data are obtained from the Turkish Statistical Institute (TUIK). In the following part of the analysis, conditional income convergence is analyzed by adding net migration rate, trade openness, per capita fiber-optic cable length, and high-school graduate rate as control variables for the 2013-2023 period. Because the dataset for the control variables does not cover the 2004--2012 period, the conditional convergence analysis is based on the shorter 2013-

-2023 period. Net migration rate is obtained from TUIK; it is based on residents of Türkiye, and refugees are not included. The high school graduate rate series is also from TUIK. Trade openness is calculated using provincial export, import, and GDP data from TUIK. Per capita fiber-optic cable length is calculated by using the provincial fiber-optic cable length series of the Information and Communication Technologies Authority (ICTA). Statistical analyses and spatial econometric estimations were performed using Python 3.13.5.

The origins of the methodology of income convergence analysis go back to Solow's (1956) growth model, which states that economies with lower capital-to-labor ratios would grow faster due to diminishing returns, and reduce income disparities over time. Barro and Sala-i-Martin (1992) and Barro (1996) formalized this concept empirically, introducing unconditional (absolute) and conditional beta convergence.

The first step of the analysis is testing unconditional income convergence across the provinces of Türkiye for 2004-2023, and also for four sub-periods such as 2004-2013, 2013-2023, 2013-2020, and 2020-2023. The absolute convergence hypothesis assumes that all provinces share the same steady-state equilibrium, with growth differences driven mainly by initial income levels. First, income convergence is investigated by analyzing the figures for all periods. Then, it is tested using the cross-sectional regressions rather than panel models because the objective is to examine whether provinces converge toward a common steady state over a given period. Following the conventional approach established by Barro and Sala-i-Martin (1992), average growth over each period is regressed on the initial income level. Introducing province-specific fixed effects in a panel framework would allow each province to have its own steady-state equilibrium, thereby shifting the analysis from absolute to conditional convergence. For this reason, cross-sectional specification is preferred for testing unconditional convergence, while panel models are employed later in the paper to investigate spatial dependence and structural determinants. The first model specification is:

$$g_i = \alpha + \beta \ln(y_{i0}) + \varepsilon_i \quad (1)$$

In this equation, g_i is the average annual growth rate of GDP per capita in province i for the analyzed period (dependent variable), y_{i0} is the initial income level, β is the convergence coefficient, and ε_i is the error term. A negative and significant , β indicates the existence of convergence over the period. The average annual growth rate is calculated as:

$$g_i = (1/T)\ln(y_{iT}/y_{i0}) \quad (2)$$

The convergence speed (λ) and the time to halve the income disparities (half-time) are also calculated as:

$$\lambda = -(1/T)\ln(1+\beta T), Half\ life = \ln(2)/\lambda \quad (3)$$

In the second step of the analysis, the model is extended to test conditional income convergence by inclusion of control variables. The control variables are: 1) *mig* : net migration rate represents the demographic mobility, 2) *open* : trade openness represents the economic integrity, 3) *fiber*: per capita fiber cable length represents the digital infrastructure, and 4) *edu:* high school graduate ratio represents the human capital. The extended model is:

$$g_i = \alpha + \beta \ln(y_{i0}) + \gamma_1(mig_{i0}) + \gamma_2(open_{i0}) + \gamma_3(fiber_{i0}) + \gamma_4(edu_{i0}) + \varepsilon_i \quad (4)$$

Estimations are carried out by using robust Ordinary Least Squares (OLS) for all periods. Diagnostic tests (heteroscedasticity, normality, model specification and multicollinearity) are also performed to ensure robustness. Although the Jarque-Bera test rejects the normality of residuals for the 2020-2023 model, the coefficient estimates remain consistent under the OLS assumptions. To ensure valid statistical inference in the presence of potential departures from normality and heteroskedasticity, all cross-sectional regressions are estimated using heteroskedasticity-robust (Huber-White) standard errors. Consequently, the reported t-statistics and p-values are robust to these violations.

In the last part of the analysis, spatial dependence of income for Turkish provinces is also tested by using Moran's *I* statistics. For this test, a queen contiguity spatial weights matrix (W) is constructed manually in Excel. Under this specification, two provinces are considered neighbors if they share either a common boundary or a common vertex. The resulting binary contiguity matrix is row-standardized so that the weights associated with neighboring provinces sum to one for each province, while non-neighboring provinces receive a weight of zero. Row standardization facilitates the interpretation of spatial spillovers by expressing each province's spatial lag as the weighted average of neighboring observations. The queen contiguity criterion is preferred because it captures a broader set of geographical interactions than the rook criterion, which considers only shared boundaries. Formally,

$$w_{ij} = \begin{cases} 1, & if\ province\ i\ and\ j\ share\ a\ border, \\ 0, & otherwise, \end{cases}$$

where $w_{ii} = 0$. The matrix is subsequently row-standardized such that $\sum_j w_{ij} = 1$.

Moran's *I* statistic is expressed as;

$$I = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{\mathrm{ij}}(y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^{N}(y_i - \bar{y})^2} \tag{5}$$

N is the number of all spatial units (81), y_i is the value of the variable for unit i, w_{ij} is the spatial weight between unit i and j, and $\bar{y}$ is the mean of y across all units. Positive and significant I values indicate provinces with similar income levels cluster together; negative significant values show that high-income provinces are surrounded by low-income provinces (and vice versa); values close to zero mean that there is no spatial dependence.

With Moran's *I* statistics it is confirmed that provincial income levels in Türkiye depend on neighbouring provinces' income levels, and there are spatial spillovers. Before estimating the spatial panel models, spatial specification diagnostics were conducted following Anselin et al. (1996). The LM-Lag and LM-Error tests were first applied to the residuals of a non-spatial two-way fixed-effects model containing province and year effects. Because the ordinary LM tests may both reject their respective null hypotheses when only one form of spatial dependence is present, Robust LM-Lag and Robust LM-Error tests were also calculated.

The model-selection diagnostics indicate that the appropriate spatial specification varies across sub-periods. For the 2013-2020 period, only the Robust LM-Lag statistic is statistically significant, providing support for the Spatial Autoregressive (SAR) specification (Anselin et al., 1996). In contrast, for the 2020-2023 period, both Robust LM-Lag and Robust LM-Error statistics are statistically significant, suggesting that both spatial-lag and spatial-error dependence are present simultaneously. According to the spatial econometric literature, this pattern is consistent with a more general SAC/SARAR process

that accommodates both forms of spatial dependence (LeSage and Pace, 2009; Elhorst, 2014). For the full 2013-2023 period, although the conventional LM-Lag and LM-Error tests reject the null hypothesis of no spatial dependence, neither the Robust LM statistic remains significant after controlling for the alternative form of dependence. Consequently, the diagnostics do not provide a clear basis for preferring either the SAR or SEM specification. Therefore, both models are estimated and reported as complementary sensitivity specifications to assess the robustness of the empirical findings across alternative representations of spatial dependence. The three spatial panel model specifications are as follows;

1) The Spatial Autoregressive (SAR) model:

$$y_{it} = \rho \sum_{j=1}^{N} w_{ij} y_{jt} + X_{it}\beta + \mu_i + \tau_t + \varepsilon_{it} \quad (6)$$

where i=1,…N are index provinces and t=1,…T index years, γ_{it} is the log of per-capita income in province i at time t (dependent variable), ρ is the spatial autoregressive coefficient measuring the strength of spatial dependence in the dependent variable, w_{ij} is the weight of neighbours, X_{it} is the vector of control variables (high school rate, net migration rate, trade openness, per-capita fiber cable length), μ_i are province fixed effects, τ_t are year effects, and ε_{it} is the error term.

In the SAR model, the estimated coefficients of the explanatory variables do not directly represent their marginal effects on provincial income, since changes in an explanatory variable in one province may affect neighbouring provinces through spatial feedback mechanisms. The total marginal effect of an explanatory variable is determined by the spatial multiplier, expressed as;

$$(I\ \rho W)^{-1}$$

where (I) is the identity matrix, (ρ) is the spatial autoregressive coefficient, and (W) is the spatial weights matrix.

Accordingly, the overall impact of each explanatory variable can be decomposed into direct, indirect, and total effects. Direct effects capture the average impact of changes in an explanatory variable within a province on its own income, including feedback effects through neighbouring provinces. Indirect effects represent the average spillover effects on other provinces, while total effects are the sum of direct and indirect effects. Although this decomposition provides a more comprehensive interpretation of the marginal impacts in spatial autoregressive models, the primary objective of the SAR specification in this study is to identify and assess the presence and strength of spatial dependence in provincial income. Therefore, the spatial autoregressive coefficient (ρ) and the estimated regression coefficients are reported to characterize spatial dependence and the conditional relationships between explanatory variables and provincial income, rather than to quantify decomposed marginal effects.

2) The Spatial Error (SEM) model:

$$y_{it} = X_{it}\beta + \mu_i + \tau_t + u_{it} \quad (7)$$

$$u_{it} = \lambda \sum_{j=1}^{N} w_{ij} u_{jt} + \varepsilon_{it} \quad (8)$$

Where the structural error u_{it} follows a spatial autoregressive process with coefficient λ.

3) The Spatial Autoregressive Combined (SAC/SARAR) model:

$$y_{it} = \rho \sum_{j=1}^{N} w_{ij} y_{jt} + X_{it}\beta + \mu_i + \tau_t + u_{it}$$

$$u_{it} = \lambda \sum_{j=1}^{N} w_{ij} u_{jt} + \varepsilon_{it}$$

Here, ρ represents the degree of spatial dependence in provincial income, whereas λ measures spatial dependence in the disturbance term. Accordingly, the model captures both substantive spatial interactions among neighboring provinces and spatially correlated unobserved factors.

3. Results

This section presents the empirical findings in three stages. First, absolute income convergence across Turkish provinces is examined using graphical analysis and cross-sectional regressions for the full sample and selected sub-periods. Second, conditional convergence is evaluated by incorporating structural determinants of regional growth. Third, the presence of spatial dependence is investigated using Moran's *I* statistics and a provincial income map. At the final stage, spatial panel econometric models are also estimated to assess the effects of neighboring provinces and spatially correlated shocks on provincial income dynamics.

3.1. Absolute Convergence Results

The analysis starts with a visual inspection by drawing scatterplots of initial income and economic growth for the provinces. Figure 1(a), the scatterplot for the 2004-2023 period illustrates a clear negative relationship between initial income levels and growth rates. This figure provides evidence for the existence of absolute income convergence among the provinces of Türkiye for the 2004-2023 period. According to this evidence, provinces with lower initial income levels in 2004 experienced higher average growth rates over the following two decades.

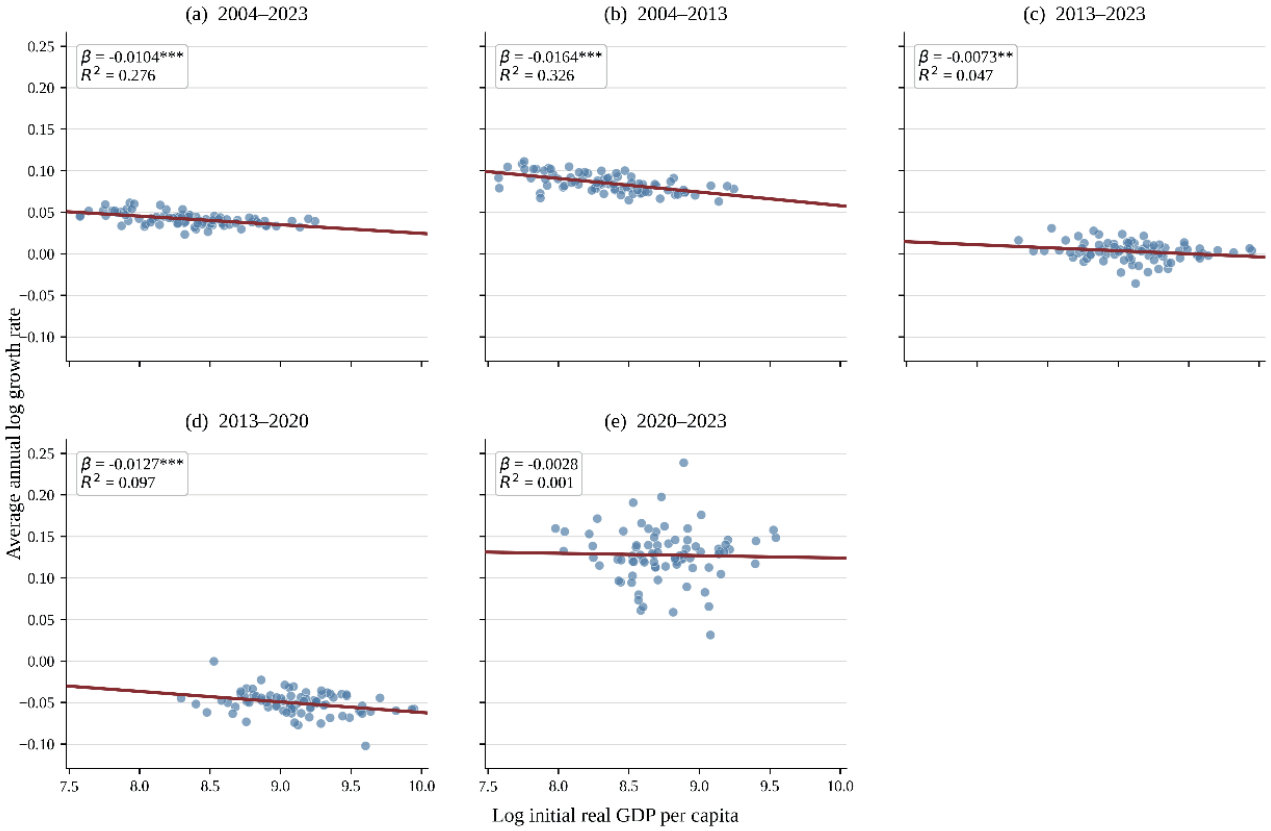


Figure 1: Provincial Income Convergence in Türkiye (2004-2023, 2004-2013, 2013-2023, 2013-2020, 2020-2023)
(Source: Created by the author.)

Notes: Each point represents one province (N = 81). The horizontal and vertical axes show the logarithm of initial real GDP per capita and the average annual growth rate, respectively. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

As a next step, scatterplots for the sub-periods (2004-2013, 2013-2023, 2013-2020, and 2020-2023) are investigated to detect whether the income convergence is continuous or not. Figure 1(b) shows that during the 2004-2013 period, a negative relationship is observed between initial income level and the average growth rate. During the first decade, there is absolute income convergence. According to Figure 1(c), in the 2013-2023 period, the scatter plot becomes flatter, which indicates a slowdown in income convergence among the provinces. Figure 1(d) shows a weak but still negative relationship between initial income and the average growth rate for the 2013-2020 period. For this period, the catch-up process is ongoing but at a lower speed. Figure 1(e), covering the 2020-2023 post-pandemic period, shows an almost flat scatter plot. This indicates that there is no evidence of income convergence among the provinces. Since this is a short period, it is important to investigate whether it is a temporary stagnation of convergence or a structural shift to a divergence process.

The scatter plots indicate absolute income convergence between 2004-2023 period. But when we check the sub-periods, the convergence is stronger between 2004-2013, and slows down afterwards. The absolute convergence behavior is also tested by regression analysis.

In Table 1, for all the periods the sign of the beta coefficient is negative, but it is not statistically significant for the 2020-2023 period. For the 2004-2013 period, the beta coefficient is -0.0164; for the 2013-2020 period it is -0.0127. These decreasing coefficients indicate a slowdown in income convergence. During the last period, the beta coefficient is -0.0028, and it is not statistically significant. In sum, convergence

was stronger before 2013, it slowed down until 2020, but stopped after 2020. A comparison of convergence speeds and half-lives shows that the catch-up process was fastest during 2004-2013.

The sub-period results coincide with important changes in Türkiye's macroeconomic environment. The 2004-2013 period was characterized by relatively strong growth and greater macroeconomic stability, while the years after 2013 involved slower growth and increased economic volatility. Although average real income recovered after 2020, provincial convergence did not resume, suggesting that aggregate economic recovery alone was insufficient to reduce regional income disparities.

Table 1: Absolute Convergence Results (Source: Created by the author.)

Period	2004-2023	2004-2013	2013-2023	2013-2020	2020-2023
ln(initial income)	-0.0104*** (0.0018)	-0.0164*** (0.0029)	-0.0073** (0.003)	-0.0127*** (0.0048)	-0.0028 (0.0094)
Constant	0.1285*** (0.015)	0.2218*** (0.0249)	0.0691** (0.0274)	0.0649 (0.0442)	0.1520* (0.082)
Observations (N)	81	81	81	81	81
R^2	0.276	0.326	0.047	0.097	0.001
Adjusted R^2	0.267	0.318	0.035	0.086	-0.012
Convergence speed (λ)	0.0116	0.0177	0.0076	0.0133	0.0028
Half-life (years)	59.8	39.1	91.7	52.2	247.3

Notes: Dependent variable is the average annual log growth rate of real per-capita income. Robust standard errors are in parentheses. ***, **, * denote significance at 1%, 5%, 10% levels, respectively.

3.2. Conditional Convergence Results

Conditional income convergence is examined by including control variables. The roles of net migration rate, trade openness, per capita fiber-optic cable length, and human capital on the average per capita income growth are tested. Because the dataset for the control variables does not cover the 2004-2012 period, the conditional income convergence analysis is based on the 2013-2023 period and its two sub-periods (2013-2020 and 2020-2023).

Table 2 presents the conditional convergence results. For all three periods, the beta coefficient has a negative sign, but it is only significant for the 2013-2020 period. For 2013-2023 and 2020-2023, it is not statistically significant. This indicates that there is evidence of income convergence for 2013-2020, but convergence stops during 2020-2023. When we look at the outcomes for the control variables, the coefficient of migration is only significant for the 2020-2023 period and its sign is positive. Provinces experiencing net in-migration tended to grow faster. The coefficient of trade openness is significant and positive for 2013-2023 and 2013-2020, and it is insignificant for 2020-2023. During 2013-2020, provinces that benefited from trade relations had higher growth rates, and trade supported income convergence. More trade-oriented provinces grew faster, suggesting that integration with external markets is an important driver of income convergence. However, during the last period, the contribution of trade to convergence dissepeared. For the per capita fiber-optic cable length, which is a proxy for digital infrastructure, the coefficient is positive and significant for 2013-2020, indicating that digital infrastructure promotes income convergence. On the other hand, for the last period, digitalization has a negative significant effect on economic growth. This result may be due to the rapid expansion of digital infrastructure that did not immediately translate into provincial income growth. The coefficients of high school graduate rates are not significant.

Table 2: Conditional Convergence Results (Source: Created by the author.)

Period	2013-2023	2013-2020	2020-2023
ln(initial income)	-0.0076 (0.0070)	-0.0230** (0.0099)	-0.0022 (0.0102)
Net migration rate	-0.0001 (0.0002)	-0.0000 (0.0002)	0.0005** (0.0002)
Trade openness	0.0196** (0.0079)	0.0386*** (0.0117)	-0.0041 (0.0093)
Fiber per capita	-0.0007 (0.0010)	0.0025** (0.0011)	-0.0045*** (0.0014)
High-school rate	-0.0001 (0.0006)	0.0002 (0.0007)	0.0003 (0.0016)
Constant	0.0736 (0.0558)	0.1389* (0.0777)	0.1715** (0.0743)
Observations (N)	81	81	81
R^2	0.202	0.241	0.246
Adjusted R^2	0.149	0.191	0.196
Convergence speed (λ)	0.0079	0.0251	0.0022
Half-life (years)	87.9	27.6	311.3

Notes: Dependent variable is the average annual log growth rate of real per-capita income. Robust standard errors are in parentheses. ***, **, * denote significance at 1%, 5%, 10% levels, respectively.

With the inclusion of the control variables, for the 2013-2020 period catch-up speed increased from 1.33% to 2.51%, and half-life decreased from 52.2 to 27.6 years. For this period, trade openness and digital infrastructure were statistically significant variables that contributed to income convergence.

To ensure the reliability of the estimations, a set of diagnostic tests were conducted. Across all periods, F-statistics were significant, confirming that the explanatory variables jointly contribute to explaining cross-provincial income growth. For heteroscedasticity, the Breusch-Pagan and White tests were performed. According to both tests, there is mild heteroscedasticity across provinces for the first two periods. However, since robust standard errors were used, this issue does not bias the coefficients or invalidate significance levels. According to the Ramsey RESET test for model specification, the model's log-linear specification adequately captures the relationship between provincial income growth and its determinants. The Jarque-Bera test indicates that residuals follow an approximately normal distribution, except for the 2020-2023 model. To assess potential collinearity among regressors, Variance Inflation Factors (VIFs) were calculated. All values lie below the conventional threshold of 5, suggesting that multicollinearity does not distort coefficient estimates.

Table 3: Diagnostic Tests for Conditional Convergence Models (Source: Created by the author.)

Period	2013-2023	2013-2020	2020-2023
N	81	81	81
R^2	0.202	0.241	0.246
F-statistic	3.805	4.773	4.896
Prob(F)	0.004	0.001	0.001
BP (χ^2)	16.519	10.085	7.671
BP p	0.006	0.073	0.175
White (χ^2)	40.576	46.808	21.685
White p	0.004	0.001	0.358
JB statistic	0.96	1.606	18.537
JB p-value	0.619	0.448	9.43E-05
Mean VIF	2.004	2.004	1.758
Max VIF	2.72	2.72	2.295
RESET F	0.103	0.057	0.318
RESET p	0.75	0.812	0.575

3.3. Spatial Distribution and Spatial Dependence Results

At the final stage of the analysis, the regional structure in Türkiye's income distribution is tested by measuring the correlation of income between neighboring provinces. In Table 4, high and statistically significant Moran's *I* values indicate a strong relationship between the neighboring provinces' income levels. Persistent and significant positive autocorrelation reflects regional polarization. Provinces close to wealthy industrial centers tend to share high income levels, whereas peripheral regions remain spatially and economically isolated. This pattern aligns with the findings in the regional convergence literature on Türkiye (Gezici and Hewings, 2004), which emphasize the spatial dimension of inequality.

Table 4: Moran's I Results for Provincial Per Capita Income (Source: Created by the author.)

Year	Moran's I	Z-score	p-value
2004	0.658	7.83	0.000 ***
2005	0.665	7.96	0.000 ***
2006	0.662	7.88	0.000 ***
2007	0.659	7.80	0.000 ***
2008	0.664	7.91	0.000 ***
2009	0.663	7.89	0.000 ***
2010	0.660	7.82	0.000 ***
2011	0.652	7.62	0.000 ***
2012	0.640	7.35	0.000 ***
2013	0.616	6.83	0.000 ***
2014	0.666	7.98	0.000 ***
2015	0.688	8.43	0.000 ***
2016	0.685	8.36	0.000 ***
2017	0.670	8.03	0.000 ***
2018	0.672	8.07	0.000 ***
2019	0.656	7.73	0.000 ***
2020	0.637	7.33	0.000 ***
2021	0.643	7.45	0.000 ***
2022	0.674	8.10	0.000 ***
2023	0.664	7.89	0.000 ***

In addition to Moran's *I* test, the geographical distribution of income levels in 2023 is visualized in Figure 2. Provinces are grouped into five income categories based on their real GDP per capita. The map shows a clear geographical concentration of relatively high-income provinces in western and northwestern Türkiye, particularly around the country's major industrial and metropolitan centers. In contrast, relatively low-income provinces are concentrated mainly in eastern and southeastern Türkiye. The tendency of neighboring provinces to belong to similar income categories is consistent with the positive and statistically significant Moran's *I* result for 2023. The map therefore provides descriptive visual support for the presence of positive spatial autocorrelation in provincial income levels.

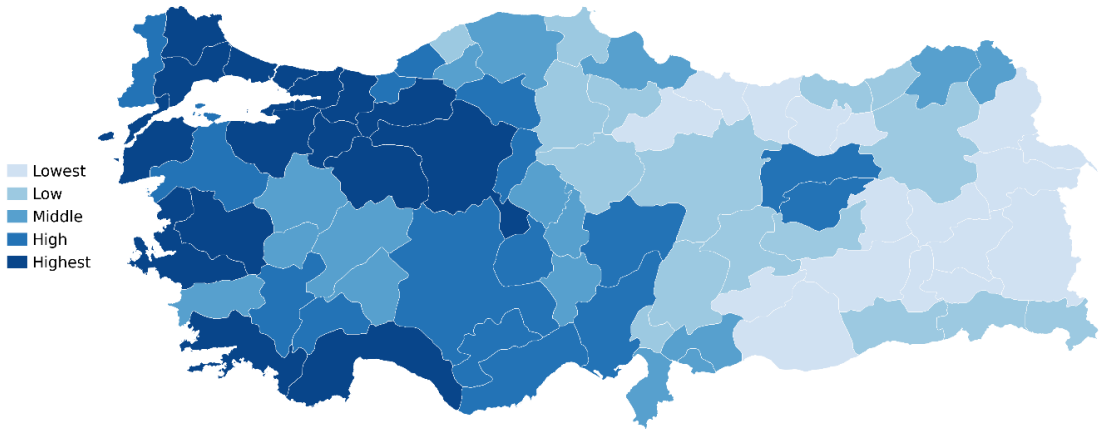


Figure 2: Provincial Distribution of Real GDP per Capita in Türkiye, 2023
(Source: Author's calculations based on TÜİK data.)
Note: Provinces are classified into five groups according to their real GDP-per-capita levels. Darker shading represents higher provincial income. Provincial boundaries are based on the GADM administrative boundary database, and income data are obtained from TÜİK.

The persistence of this spatial clustering indicates that provincial income levels cannot be treated as spatially independent. Since Moran's *I* confirms spatial autocorrelation, the econometric framework is extended to incorporate spatial dynamics. However, Moran's *I* only indicates the existence of spatial dependence and does not identify its underlying source. Spatial dependence may arise through interactions among neighbouring provinces, represented by a spatially lagged dependent variable, or through spatial correlation in the error term resulting from omitted regional characteristics. Consequently, Lagrange Multiplier (LM) tests and their robust versions proposed by Anselin et al. (1996) are employed to determine the most appropriate spatial specification. While the standard LM-Lag and LM-Error statistics test for the presence of spatial dependence in the dependent variable and the disturbance term, respectively, the Robust LM tests account for the possible coexistence of both forms of spatial dependence and therefore provide a more reliable basis for model selection.

Table 5 presents the LM diagnostic results for the three estimation periods. For the 2013-2023 period, both the LM-Lag and LM-Error statistics are highly significant, indicating the presence of spatial dependence. However, neither the Robust LM-Lag nor the Robust LM-Error statistic remains statistically significant, suggesting that the diagnostics do not clearly distinguish between spatial lag and spatial error dependence. Consequently, both the SAR and SEM models are estimated and compared for this period.

For the 2013-2020 period, both LM statistics are again statistically significant. More importantly, only the Robust LM-Lag statistic remains significant, whereas the Robust LM-Error statistic is insignificant. This result indicates that spatial dependence primarily operates through interactions among neighbouring provinces rather than through spatially correlated omitted factors. Accordingly, the SAR model is the preferred specification for this period.

The diagnostic results differ for the 2020-2023 period. Although both conventional LM statistics remain highly significant, both Robust LM-Lag and Robust LM-Error tests are also statistically significant. This finding indicates that spatial dependence simultaneously exists in the spatial lag of the dependent variable and in the disturbance term. Therefore, neither the SAR nor the SEM model alone adequately captures the spatial dependence structure. Instead, a more general SAC/SARAR specification, which jointly models spatial interaction and spatially correlated disturbances, is estimated for the post-pandemic period. These results suggest that regional income dynamics became considerably more complex after 2020, reflecting both stronger interregional spillover effects and spatial dependence arising from unobserved regional shocks.

Table 5: Lagrange Multiplier Tests for Spatial Model Selection (Source: Created by the author.)

Test	2013-2023	2013-2020	2020-2023
LM-Lag	141.787***	29.195***	69.162***
	(<0.001)	(<0.001)	(<0.001)
LM-Error	142.136***	24.560***	57.288***
	(<0.001)	(<0.001)	(<0.001)
Robust LM-Lag	0.149	6.553**	22.073***
	(0.700)	(0.010)	(<0.001)
Robust LM-Error	0.498	1.918	10.199***
	(0.480)	(0.166)	(0.001)
Preferred specification	SAR / SEM†	SAR	SAC/SARAR

Notes: The table reports Lagrange Multiplier (LM) and Robust LM statistics for testing spatial lag and spatial error dependence following Anselin, Bera, Florax, and Yoon (1996). Numbers in parentheses are *p*-values. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. †For the 2013-2023 period, neither the Robust LM statistic is statistically significant; therefore, the diagnostic tests do not identify a unique preferred specification, and both SAR and SEM models are reported as alternative specifications.

Table 6 reports the estimated spatial panel models for the three sample periods. Consistent with the LM diagnostics presented in Table 5, both the SAR and SEM models are reported for the 2013-2023 period; the SAR model is adopted for 2013-2020, and the SAC/SARAR model is estimated for the 2020-2023 period.

Table 6: Spatial Panel Regression Results (SAR, SEM and SAC/SARAR) (Source: Created by the author.)

Variable	SAR 2013-2023	SEM 2013-2023	SAR 2013-2020	SAC/SARAR 2020-2023
Net migration rate	0.00008	0.00011	0.00032**	−0.00032*
	(0.00013)	(0.00014)	(0.00013)	(0.00017)
Trade openness	0.00829	0.01154	−0.01952	0.12441***
	(0.02048)	(0.02008)	(0.02536)	(0.04265)
Fiber cable length per capita	0.00219	0.00492	0.01673***	−0.01093
	(0.00270)	(0.00300)	(0.00349)	(0.00816)
High-school graduate share	0.00536***	0.00634***	0.00824***	−0.00871*
	(0.00179)	(0.00221)	(0.00227)	(0.00523)
Spatial lag coefficient, ρ	0.46240***	—	0.29474***	0.77580***
	(0.03817)	—	(0.05290)	(0.05625)
Spatial error coefficient, λ	—	0.46671***	—	−0.62028***
	—	(0.03785)	—	(0.14055)
Province fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	891	891	648	324

Notes: Dependent variable is the log of per-capita income in province i at time t (γ_{it}), Maximum-likelihood standard errors are in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

For the 2013-2023 period, both the spatial autoregressive coefficient (ρ = 0.462) and the spatial error coefficient (λ = 0.467) are positive and highly significant, confirming the presence of spatial dependence in regional income. The significance of the spatial lag parameter indicates that economic performance in one province is positively influenced by the income levels of neighbouring provinces, reflecting regional spillover effects. However, the estimated spatial autoregressive coefficient does not directly measure the magnitude of marginal spillover effects, as these depend on the spatial multiplier and the feedback mechanisms embedded in the SAR model. Similarly, the estimated coefficients of the explanatory variables should be interpreted as conditional regression parameters rather than direct marginal effects. A formal decomposition into direct, indirect, and total effects would be required to quantify these impacts separately. Among the explanatory variables, only the proportion of high-school graduates has a positive and statistically significant coefficient in both the SAR and SEM specifications, while net migration, trade openness, and fiber-optic infrastructure do not exhibit statistically significant coefficients.

The results for the 2013-2020 period reveal a somewhat different pattern. The positive and highly significant spatial lag coefficient (ρ = 0.295) confirms that positive spatial dependence remained statistically significant. During this period, net migration and fiber-optic cable infrastructure exert positive and statistically significant effects on regional income, suggesting that provinces attracting population and expanding digital infrastructure experienced stronger economic performance. The high-school

graduate ratio also remains positive and significant, highlighting the continued importance of human capital in supporting regional development. Trade openness, however, does not have a statistically significant effect during this period.

The post-pandemic period (2020-2023) exhibits a substantially different spatial structure. The SAC/SARAR model identifies a strong positive spatial lag coefficient ($\rho = 0.776$), indicating that regional income became considerably more dependent on neighbouring provinces during the recovery period. At the same time, the negative and statistically significant spatial error coefficient ($\lambda = -0.620$) suggests that, after controlling for direct spatial spillovers, unobserved regional shocks display negative spatial dependence, implying increasing spatial heterogeneity in province-specific factors. Unlike the earlier periods, trade openness emerges as the strongest positive determinant of regional income, indicating that provinces with greater integration into external markets recovered more rapidly following the pandemic. Fiber-optic infrastructure is no longer statistically significant, while the coefficients of net migration and the high-school graduate ratio are only weakly significant, suggesting that structural regional characteristics played a more limited role in explaining short-run differences in economic performance during the recovery period.

The estimated coefficients of the high-school graduate rate differ across model specifications and sample periods. In the cross-sectional conditional convergence models, the variable is statistically insignificant, whereas it becomes positive and statistically significant in the spatial panel models for the 2013-2023 and 2013-2020 periods. This difference reflects the fact that the two approaches identify different sources of variation. The cross-sectional regressions explain average provincial growth over each period, while the spatial panel models exploit both the cross-sectional and time-series variation after controlling for province-specific effects, year effects, and spatial dependence. The spatial panel analysis indicates that human capital emerges as an important determinant of provincial income, although its contribution appears weaker during the post-2020 period.

Overall, the spatial panel results indicate that spatial dependence remains a persistent feature of regional income dynamics in Türkiye, although both the strength of spatial interactions and the determinants of regional growth changed over time. Before the pandemic, human capital, migration, and digital infrastructure contributed more strongly to regional economic performance, whereas the post-pandemic period was characterised by intensified spatial spillovers and a greater role for trade openness. These findings highlight that regional development policies should account not only for province-specific characteristics but also for the spatial interactions linking neighbouring regions.

The empirical findings are broadly consistent with earlier studies on regional income convergence in Türkiye, which generally report evidence of β-convergence while emphasizing the persistence of regional disparities (e.g., Filiztekin, 1998; Gezici and Hewings, 2004; Yıldırım and Öcal, 2006; Karahasan, 2015; Ursavaş and Mendez, 2023). However, unlike much of the earlier literature, the present study shows that the speed of convergence has weakened substantially in recent years and becomes statistically insignificant during the 2020-2023 period. Furthermore, by explicitly incorporating spatial dependence and digital infrastructure, this study demonstrates that regional interactions and digital connectivity constitute important dimensions of regional income dynamics that have received limited attention in previous studies.

4. Conclusion

This study has examined income convergence across Turkish provinces by combining traditional convergence analysis with spatial econometric methods and a detailed sub-period perspective. Using provincial data covering the 2004-2023 period, the analysis documents how convergence dynamics have evolved over time and how they are shaped by structural factors and spatial interactions. The findings demonstrate that regional income differences in Türkiye cannot be fully understood without accounting for both temporal heterogeneity and geographic dependence.

The findings from the unconditional convergence analysis indicate that convergence across provinces has been slow and uneven. While evidence of absolute convergence is observed in several periods, the estimated convergence speeds remain modest and vary considerably across sub-periods. This suggests that national growth alone has not been sufficient to substantially narrow regional income gaps. Periods of greater macroeconomic stability are generally associated with faster income convergence, while periods of high volatility tend to slow or reverse convergence. These results underline the importance of examining convergence dynamics in a time-sensitive manner rather than relying solely on long-run averages.

The conditional convergence analysis provides further insights into the structural determinants of provincial income dynamics. The study contributes to the literature by incorporating digital infrastructure into the analysis of regional convergence in Türkiye. Measured by per-capita fiber-optic cable length, it is found to be positively related to income levels prior to 2020, highlighting the growing importance of connectivity and digital capacity in regional development. These findings suggest that digital infrastructure should be considered alongside conventional determinants such as education, migration, and trade openness when examining regional disparities. Human capital, as proxied by the high-school graduate share, is a factor associated with higher income levels in the medium run, although its role appears to weaken in the post-2020 period. Migration and trade openness exhibit more nuanced and period-dependent effects, reflecting the complex interaction between mobility, market integration, and regional labor market conditions. Taken together, the results support the view that convergence in Türkiye is conditional on structural characteristics and that differences in these characteristics contribute to the persistence of regional disparities.

Another important contribution of the study lies in its explicit treatment of spatial dependence. The spatial autoregressive and spatial error panel models reveal statistically significant spatial dependence in provincial income across the estimation periods. The positive and significant spatial autoregressive coefficients indicate that income levels in Turkish provinces are spatially interconnected, while the spatial error component points to spatial correlation in unobserved regional factors. Although the estimated SAR coefficients provide evidence of spatial dependence, the direct, indirect, and total marginal effects have not been separately quantified in this study. Nevertheless, the results demonstrate that provincial economies are embedded in a broader geographic system and that regional income dynamics cannot be fully understood without accounting for spatial interactions and geographically correlated unobserved factors.

The findings have important implications for regional development policy in Türkiye. Although national development plans and regional development programmes have long sought to reduce regional disparities through investments in infrastructure, human capital, innovation, and regional competitiveness, the results indicate that the pace of income convergence has weakened over time and disappeared during the 2020-2023 period. From a policy perspective, these findings suggest that reducing regional income disparities requires greater attention to region-specific conditions and spatial interactions. Investments in education and digital infrastructure appear particularly important for supporting income growth in lagging regions, although their effectiveness is likely to depend on complementary factors such as migration patterns and regional integration. Furthermore, the strong spatial dependence identified in the analysis indicates that regional policies should not be designed in isolation but should explicitly account for interregional spillover effects and promote coordination among neighbouring provinces. Overall, the findings support the objectives of Türkiye's regional development framework by emphasizing the importance of location-based and spatially coordinated development strategies.

Overall, this study contributes to the literature by providing an updated and spatially informed assessment of income convergence across Turkish provinces. By combining sub-period analysis

with spatial panel econometric techniques and incorporating both traditional and emerging structural determinants, it offers a more comprehensive understanding of regional income dynamics in Türkiye and provides an empirical basis for future research and evidence-based regional development policies.

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Declaration of Conflict

No potential conflict of interest was declared by the author.

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Compliance with Ethical Standards

It has been declared by the author that the tools and methods used in the study do not require Ethics Committee Permission.

Ethics Statement

Scientific and ethical principles have been adhered to by the author in this Study. It has been declared that all studies used are stated in the bibliography.

References

Akkay, R. C. (2022). Income convergence among Turkish provinces: An income inequality approach. *Ekonomi Politika ve Finans Araştırmaları Dergisi,* 7(2), 274–300.

Aksoy, T., Taştan, H., and Kama, Ö. (2019). Revisiting income convergence in Turkey: Are there convergence clubs? *Growth and Change,* 50(3), 1185–1217.

Anselin, L., Bera, A. K., Florax, R., and Yoon, M. J. (1996). Simple diagnostic tests for spatial dependence. *Regional science and urban economics,* 26(1), 77-104.

Barro, R. J. and Sala-i-Martin, X. (1992). Convergence. *Journal of Political Economy,* 100(2), 223–251.

Barro, R. J. (1996). Determinants of economic growth: A cross-country empirical study, NBER Working Paper, No. 5698

Bozdoğan, A. (2024). Stochastic convergence of income in Türkiye: A methodological reinvestigation of provinces. *Journal of Research in Economics,* 8(2), 166–190.

Çınar, İ. T., and Sağdıç, E. N. (2020). Convergence of agricultural sector, non-agricultural sector, public expenditures and migration in Turkey: A spatial panel approach. *Tarım Ekonomisi Dergisi,* 26(1), 51-61.

Doğan, T., and Kındap, A. (2019). Regional economic convergence and spatial spillovers in Turkey. *International Econometric Review,* 11(1), 1–23.

Elhorst, J. P. (2014). *Spatial Econometrics: From Cross-Sectional Data to Spatial Panels.* Springer. https://doi.org/10.1007/978-3-642-40340-8

Elmalı, K., Erkal, G., and Özer, H. (2021). Türkiye'de iller arası gelir yakınsaması: Mekansal ekonometrik yaklaşım. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi,* 35(2), 451–468.

Gezici, F., and Hewings, G. J. D. (2004). Regional convergence and the economic performance of peripheral areas in Turkey. *Review of Urban & Regional Development Studies,* 16(2), 113–132.

Güçlü, M. (2010). Regional income convergence in Turkey: A Spatial Econometric Perspective. *The Empirical Economics Letters,* 10(10), 1047-1054.

Filiztekin, A. (1998). Convergence across industries and provinces in Turkey. *Ekonomi-tek,* 7(3), 1-32.

Information and Communication Technologies Authority (ICTA), Annual Provincial Statistics, https://www.btk.gov.tr/yillik-il-istatistikleri, (November 1, 2025.).

Karahasan, B. (2015). Regional inequalities in Turkey: post 2001 Era. *Marmara Üniversitesi İktisadi ve İdari Bilimler Dergisi,* 37(1), 125-147.

Karahasan, B. C. (2017). Distributional dynamics of regional incomes in Turkey: 1987 2014. *Marmara İktisat Dergisi,* 1(1), 95-107.

Le Gallo, J., and Ertur, C. (2003). Exploratory spatial data analysis of the distribution of regional per capita GDP in Europe, 1980–1995. *Papers in Regional Science,* 82(2), 175–201.

LeSage, J. P., and Pace, R. K. (2009). *Introduction to Spatial Econometrics.* CRC Press.

Lim, U. (2016). Regional income club convergence in US BEA economic areas: A spatial switching regression approach. *The Annals of Regional Science,* 56(1), 273–294.

Lim, U., and Kim, D. (2015). Toward sustainable economic growth: A spatial panel data analysis of regional income convergence in US BEA economic areas. *Sustainability,* 7(8), 9943–9959.

Peiró-Palomino, J., Prieto-Bustos, W. O., and Tortosa-Ausina, E. (2023). Regional income convergence in Colombia: Population, space, and long-run dynamics. *The Annals of Regional Science,* 70(2), 559–601.

Ramajo, J., Marquez, M. A., Hewings, G. J. D., and Salinas, M. M. (2008). Spatial heterogeneity and interregional spillovers in the European Union: Do cohesion policies encourage convergence across regions? *European Economic Review,* 52(3), 551–567.

Rey, S. J., and Montouri, B. D. (1999). US regional income convergence: A spatial econometric perspective. *Regional Studies,* 33(2), 143–156.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics,* 70(1), 65–94.

Tansel, A., and Güngör, N. D. (1999). Economic growth and convergence: An application to the provinces of Turkey, 1975-1995. Economic Research Forum for the Arab Countries, Iran & Turkey.

Turkish Statistical Institute (TUIK), Regional Statistics, https://biruni.tuik.gov.tr/bolgeselistatistik/sorguGiris.do, (November 1, 2025.).

Ursavaş, U., and Mendez, C. (2023). Regional income convergence and conditioning factors in Turkey: revisiting the role of spatial dependence and neighbor effects. *The Annals of Regional Science,* 71(2), 363-389.

Yıldırım, J., and Öcal, N. (2006). Income inequality and economic convergence in Turkey. *Transition Studies Review,* 13(3), 559-568.