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AGRICULTURE AND REGIONAL DEVELOPMENT: SPATIAL INSIGHTS FROM TURKISH PROVINCES

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Abstract

This study investigates the impact of agricultural activities on regional economic growth in Turkey over the period 2008–2020. Utilizing a balanced panel dataset for 81 NUTS-3 provinces, the analysis is grounded in the Augmented Solow–Swan Growth Model proposed by Mankiw, Romer, and Weil (1992). Spatial econometric techniques are employed to assess spatial dependence and interregional linkages. Hausman test outcomes identify the Spatial Durbin Model (SDM) as the most appropriate specification. The empirical findings reveal that agricultural production exerts a positive and statistically significant influence on regional economic growth (coefficient = 0.037). While the direct effect is significant (0.046), both the indirect (0.108) and total (0.155) effects are positive yet statistically insignificant, indicating limited spatial spillovers across provinces. These results suggest that agriculture supports local economic performance but does not induce strong cross-regional diffusion effects. The study is limited to provincial-level data for 2008–2020, and results may vary with alternative spatial weight matrices or structural changes beyond this period. Policy implications highlight the need to complement agricultural support with improvements in human capital, infrastructure, and technology to enhance regional convergence. The study contributes to the literature by integrating spatial econometrics with the Solow–Swan framework and offering novel evidence on agriculture–growth dynamics in Turkey.

Keywords: Agriculture Economic Growth, Regional Economics, Spatial Panel Data Analysis

Bölgesel Kalkınmada Tarımın Katkısı: Türkiye İllerinden Mekansal Bulgular

Öz

Bu çalışma, 2008–2020 döneminde Türkiye’de tarımsal faaliyetlerin bölgesel ekonomik büyüme üzerindeki etkilerini incelemektedir. Türkiye’nin 81 ilinden oluşan dengeli panel veri seti kullanılarak gerçekleştirilen analiz, Mankiw, Romer ve Weil (1992) tarafından geliştirilen Genişletilmiş Solow–Swan Büyüme Modeli temelinde yürütülmüştür. Mekânsal

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bağımlılık ve iller arası etkileşimleri test etmek amacıyla mekânsal ekonometrik yöntemler uygulanmış, Hausman testi sonuçları en uygun modelin Mekânsal Durbin Modeli (SDM) olduğunu göstermiştir. Bulgular, tarımsal üretimin bölgesel ekonomik büyüme üzerinde pozitif ve istatistiksel olarak anlamlı bir etkiye sahip olduğunu (katsayı = 0.037) ortaya koymaktadır. Doğrudan etkinin anlamlı (0.046) olduğu, ancak dolaylı (0.108) ve toplam (0.155) etkilerin pozitif fakat istatistiksel olarak anlamlı olmadığı görülmektedir. Bu sonuçlar, tarımın yerel ekonomik performansı desteklediğini ancak bölgeler arası yayılma etkilerinin sınırlı kaldığını göstermektedir. Çalışmanın 2008–2020 dönemi ve il düzeyiyle sınırlı olması, farklı mekânsal ağırlık matrislerinin alternatif sonuçlar üretebilmesi gibi kısıtları bulunmaktadır. Politika çıkarımları, tarımsal desteğin beşerî sermaye, altyapı ve teknoloji yatırımlarıyla tamamlanması gerektiğini vurgulamaktadır. Çalışma, mekânsal ekonometriyi Solow–Swan çerçevesiyle birleştirerek tarım–büyüme ilişkisine dair özgün kanıtlar sunmaktadır.

Anahtar Kelimeler: Tarım, Ekonomik Büyüme, Bölgesel İktisat, Mekansal Panel Veri Modelleri

Introduction

The agricultural sector plays a fundamental role in achieving economic development, particularly in developing countries. By ensuring food security and enhancing rural employment, agriculture occupies a strategic position and constitutes a central component of the economy in low- and middle-income countries (Johnston & Mellor, 1961). Its impact extends beyond direct contributions, exerting profound indirect effects on national economies. In this context, agriculture should not be viewed merely as a primary production activity but also as a critical supplier of inputs to the industrial and service sectors. Moreover, given its influence on income distribution and its contribution to poverty reduction, agriculture represents a multidimensional sector of strategic significance (Timmer, 2012). Increases in agricultural output can generate wide-ranging macroeconomic effects through linkages with input markets, agro-industrial activities, and rural infrastructure (Christiaensen et al., 2011). Economic growth is generally defined as the rise in per capita income accompanied by improvements in welfare, living standards, productivity, and the efficiency of resource allocation. Neoclassical growth theory identifies capital accumulation, labor supply, and technological progress as the fundamental drivers of growth (Solow, 1956). More recent models expand this

framework to include human capital, trade structure, and sectoral transformation dynamics. Additionally, institutional quality has emerged as a key determinant of the growth process (Acemoglu, 2009). Accordingly, structural transformation across agriculture, industry, and services has become a central focus in the literature, as the nature of this transition critically shapes the trajectory of sustainable growth and development in emerging economies. The relationship between agriculture and economic growth has long been a focal point in economics. Lewis's (1954) classical dual-sector model underscores that agricultural labor transfer to non-agricultural sectors facilitates the growth process. Subsequent empirical studies have shown that productivity improvements in agriculture generate both direct and indirect effects on economic growth (Gollin et al., 2007; Tiffin & Irz, 2006). Evidence from low- and middle-income countries indicates that agricultural productivity gains not only sustain economic growth but also underpin structural transformation (Self & Grabowski, 2007). Thus, agriculture should be considered not merely a passive component of growth but rather an active engine that stimulates economic expansion. When analyzing the relationships between economic variables, spatial dependence frequently arises. Ignoring spatial interactions can lead to biased and inconsistent estimates (LeSage & Pace, 2009). This concern is particularly relevant in the case of agriculture, a sector that influences economic growth both directly and indirectly. The very nature of agricultural activities—shaped by land use, water resources, climate conditions, and labor mobility—creates spatial interdependencies across regions.

Against this backdrop, the present study aims to examine the impact of agricultural activities on regional economic growth in Turkey over the period 2008–2020, using provincial-level data (NUTS-3, 81 provinces). The analysis explicitly accounts for potential spatial interactions among regions and provides a detailed assessment of the role of public investment in the growth process. The empirical framework builds on the Augmented Solow-Swan Growth Model developed by Mankiw et al. (1992), incorporating public investment alongside human capital,

technological progress, physical capital, and labor. This approach allows for the estimation of the direct, indirect, and total effects of these determinants on regional economic growth.

By analyzing not only the direct contributions of agriculture but also its spillover effects on neighboring provinces, the study provides a more comprehensive perspective for interpreting the findings. Accordingly, the empirical strategy employs spatial econometric techniques that capture both spatial dependence and spillover effects.

The study addresses the following key research questions:

Does the agricultural sector exert a significant impact on regional sustainable economic growth in Turkey?

Are there spatial dependence and spillover effects in the relationship between agriculture and regional sustainable economic growth?

In line with these questions, the study tests the following hypotheses:

H₁: The agricultural sector has a direct and statistically significant impact on regional sustainable economic growth.

H₂: The agricultural sector generates spatial dependence and spillover effects on regional sustainable economic growth.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature. Section 3 describes the data, model, and methodology. Section 4 presents the empirical findings and discussion. Section 5 concludes with policy implications.

2. Literature Review

The contribution of agriculture to economic growth has long been a central topic in the economics literature. Both theoretical and empirical studies demonstrate that the linkages between agriculture and economic growth operate through multiple channels. Increases in agricultural productivity, structural transformation, and sectoral reallocation support economic growth indirectly by facilitating the transfer of labor and capital to the industrial and service sectors. These mechanisms continue

to be reassessed within the framework of classical development economics (Timmer, 1992).

Empirical evidence suggests that improvements in agricultural productivity contribute significantly to economic growth. However, the magnitude and direction of this contribution vary depending on country-specific characteristics, such as initial income levels, the share of agriculture in value added, employment and GDP, and the degree of development in non-agricultural sectors. In this respect, analyses that account for spatial dependence and spillover effects provide more accurate estimates than standard econometric approaches, while also enabling the decomposition of direct and indirect effects (Anselin, 1988; LeSage & Pace, 2009). Gollin et al. (2010) show that productivity gains in agriculture can, through demographic dynamics and labor markets, promote long-run economic growth. Furthermore, the recent literature has increasingly emphasized the importance of spatial spillovers and regional interactions. For instance, Vroege (2020) analyzes interactions among agricultural enterprises using spatial econometric models and highlights the externalities these interactions create for economic growth. Li (2022), adopting the framework of the Internet of Things (IoT), employs spatial econometric techniques to investigate the effects of technological advancements in agriculture on economic growth, underscoring the crucial role of innovation. Particularly, agricultural innovations, infrastructure investments, and environmental or climatic shocks affect not only the regions in which they occur but also neighboring regions through spatial spillovers. Similarly, Wu et al. (2022), examining 30 regions in China, analyze the spatial effects of public agricultural expenditures on ecological efficiency. Their findings emphasize both the direct and indirect effects of agricultural spending on environmental efficiency. Meena et al. (2024) further stress the significance of incorporating spatial dependence and spillover effects in modeling agricultural development. Burnett (2025), focusing on the United States, highlights the spatial dependence of agricultural land values and the resulting regional disparities, demonstrating the economic importance of accounting for such heterogeneity.

In Turkey, the role of agriculture in economic growth has also been widely examined. Historically, agriculture has been one of the most important economic activities, both in terms of employment and income generation. Although the share of agriculture in gross domestic product (GDP) declined following the structural transformations of the 1980s, the sector has retained its strategic importance in areas such as productivity, regional development, and foreign trade. Empirical studies focusing on Turkey emphasize that agricultural support policies, fixed capital investments, and technological advances make substantial contributions to the sector and, in turn, to national income. However, the relationship between agriculture and economic growth displays both temporal and regional heterogeneity. Ünal and Seçilmiş (2013), for example, examine the effects of R&D intensity on GDP in Turkey, finding that R&D expenditures have a significant impact on economic growth and that agriculture plays a critical role in this process. Time-series and panel studies, such as those conducted by Olgun et al. (2018), report varying results regarding the agriculture–growth nexus. Spatial analyses, on the other hand, investigate the geographical distribution of agriculture, the effects of climate change, and the nature of spatial dependence and spillovers. More recent research highlights the importance of accounting for the spatial distribution of agricultural production in Turkey, underscoring the need to incorporate spatial heterogeneity and regional interdependencies into economic policy design (Karahasan et al., 2023). Elmalı (2025) The analysis reveals that per capita GDP is positively and significantly associated with non-agricultural employment, agricultural employment, and production levels. In contrast, a negative and significant relationship is observed between agricultural land area and economic growth. Moreover, considering spatial neighborhood effects, per capita GDP exhibits a negative and significant association only with non-agricultural employment.

Building on this literature, the present study aims to examine the impact of agricultural activities on regional economic growth in Turkey over the period 2008–2020, using provincial-level (NUTS-3, 81 provinces) data. The analysis explicitly

incorporates spatial interactions among provinces in order to provide a detailed assessment of the role of agriculture in the growth process. The empirical framework is based on the Augmented Solow-Swan Growth Model developed by Mankiw et al. (1992), in which, alongside agriculture, human capital, technological progress, physical capital, and labor are incorporated as key determinants of growth. This approach enables a joint evaluation of the direct, indirect, and total effects of these variables on regional economic growth.

By analyzing not only the direct contributions of agriculture but also its spillover effects on neighboring provinces, this study provides a more comprehensive and nuanced understanding of the sector's role in regional development. Accordingly, the analysis is conducted using spatial econometric techniques that capture both spatial dependence and spillover effects.

Furthermore, the study controls for the fundamental determinants of economic growth—namely physical capital, human capital, technological progress, and labor. Its methodology and scope offer three key contributions to the literature: (i) it provides a detailed provincial-level examination of the relationship between agriculture and economic growth in Turkey; (ii) it employs a large sample over a relatively long time horizon; and (iii) it is the first study to analyze the impact of agriculture on regional economic growth in Turkey by explicitly incorporating indirect and spillover effects.

In doing so, the study offers more precise and spatially disaggregated evidence on the role of agriculture in regional economic growth, contributing to both the academic literature and policy debates on sustainable development in Turkey.

3. Data, Model and Method

This study aims to investigate the relationship between the agricultural sector and economic growth at the provincial level (NUTS-3) within the Turkish economy. The analysis encompasses all 81 provinces, providing a comprehensive evaluation of the effects of the agricultural sector on regional economic performance. In the empirical model, provincial gross domestic product (GDP) levels are

employed as the dependent variable, while the independent variables include indicators of technological capacity, human capital, physical capital stock, and labor supply at the provincial level.

The theoretical framework of the study is grounded in the Augmented Solow-Swan Growth Model developed by Mankiw et al. (1992). Within this framework, the effects of public investment on regional economic growth are analyzed by explicitly accounting for spatial heterogeneity and potential externalities. Detailed definitions of the variables and the corresponding data sources are presented in Table 1.

Table 1: *Explanations of Variables Used in the Analysis*

Variables	Abbreviation	Description	Source
GDP	lngdp	Provincial Gross Domestic Product (USD)	TURKSTAT
Agriculture	Intar	Provincial Revenue on Agriculture	TURKSTAT
Technology	Intech	Number of Registered Patents by Province	TPI
Human Capital	Inhc	Number of Postgraduate Graduates by Provinces	YOK
Physical Capital	Ininv	Provincial Public Investments	SBB

TURKSTAT: Turkish Statistical Institute

TPI: Turkish Patent Institute

YOK: Council of Higher Education

SBB: Presidency of Strategy and Budget

Table 1 presents the variables employed in the analysis. The dependent variable, GDP (lngdp), was obtained from the Turkish Statistical Institute (TURKSTAT). The independent variables are as follows: agriculture (Intar), also sourced from TURKSTAT; technology (Intech), derived from the Turkish Patent and Trademark Office; human capital (Inhc), obtained from the Council of Higher Education; physical capital (Ininv), collected from the Presidency of Strategy and Budget; and labor (Inpop), also provided by TURKSTAT.

The methodological framework of this study is based on the Augmented Solow-Swan model developed by Mankiw et al. (1992). Mankiw and his colleagues (1992) extended the original Solow-Swan model by incorporating human capital, thereby offering a more comprehensive explanation of income disparities across

countries. In its original form, the growth model introduced by Solow (1956) and Swan (1958) considered production as a function solely of physical capital and labor inputs. The augmented version expands this foundation by explicitly incorporating human capital, thus aiming to better capture the dynamics of economic growth.

The production function in the augmented Solow-Swan model is specified in a Cobb-Douglas form:

$$Y_{(t)}=K_{(t)}^{\alpha}H_{(t)}^{\beta}[A_{(t)}L_{(t)}]^{1-\alpha-\beta} \quad (1)$$

Here:

$Y(t)$ denotes total output,

$K(t)$ denotes the physical capital stock,

$H(t)$ denotes the human capital stock,

$L(t)$ denotes labor supply,

$A(t)$ denotes the level of technology.

The parameters α and β represent output elasticities, where the condition $\alpha + \beta < 1$ ensures diminishing returns to scale. Within the framework of the augmented Solow-Swan model, both physical and human capital contribute to the growth process depending on the respective savings rates. Thus, economic growth is accelerated not only through investments in physical capital but also through investments in human capital. Human capital is represented by investments in education, health, and access to knowledge.

When models incorporating spatial dependence are employed, different types of interactions may emerge within the framework of spatial econometric analysis. These interactions can be categorized under three main headings: endogenous effects of the dependent variable, exogenous effects among the independent variables, and mutual dependence among the error terms. The fundamental models of spatial econometrics are the Spatial Autoregressive Model (SAR) and the Spatial Error Model (SEM). The SAR model, often referred to as the “spatial lag model,” captures endogenous spatial interaction, while the SEM model represents spatial dependence among the error terms (Elhorst, 2014: 5). A model

specification that simultaneously considers dependence in both endogenous effects and error components is defined in the literature as the Spatial Durbin Model (SDM) (Anselin, 1998).

The general form of the unrestricted Durbin model can be expressed as follows:

$$y = \rho Wy + \alpha_i + X\beta + WX\theta + \varepsilon \quad (2)$$

$$\varepsilon = \lambda W\varepsilon + u \quad (3)$$

In this specification, λ denotes spatial dependence among the error terms (spatial autoregressive structure), ρ denotes spatial dependence in the dependent variable, and α represents the intercept. The number of independent variables is denoted by K ; W is the $n \times n$ spatial weights matrix, y is the $n \times 1$ dependent variable vector, and X is the $n \times k$ matrix of independent variables. The parameters β and θ represent the $k \times 1$ vectors of regression coefficients. Moreover, Wy denotes the spatially lagged dependent variable, while WX represents the spatially lagged independent variables.

Within the Spatial Durbin Model (SDM), if the restrictions $\theta = 0$ are imposed, the model reduces to the Spatial Autoregressive (SAR) specification. In that case, the solution for y in the SAR model can be expressed as follows:

$$y = (I - \rho W)^{-1} X\beta + (I - \rho W)^{-1} \varepsilon \quad (4)$$

Within this framework, when the spatial dependence of the dependent variable is restricted to $\rho = 0$, the model reduces to the Spatial Error Model (SEM) (Anselin, 1988):

$$y = X\beta + (I - \lambda W)^{-1} u \quad (5)$$

where λ captures the spatial autocorrelation in the error terms, W denotes the spatial weights matrix, and ε is the vector of independently and identically distributed error terms.

When the time dimension is incorporated—such that both the variables and error terms are expressed across periods t —the specification extends to a spatial panel data model. Spatial panel models are particularly advantageous in contexts

where interactions across regions are present, as they provide a systematic framework for capturing spatial dependence. Ignoring the correlation observed among dependent and independent variables across geographically proximate regions may reduce the reliability of the results, since it is often unrealistic to assume the independence of observations between neighboring regions.

In this regard, spatial panel data models are of considerable importance, as they allow researchers to identify and econometrically disentangle neighborhood effects across regions. These models make it possible to examine how variables in a given region influence outcomes in adjacent regions, thereby enabling the decomposition of direct and indirect (spillover) effects. This decomposition not only enhances the robustness and reliability of the empirical findings but also provides a more consistent and comprehensive economic interpretation. Consequently, the use of spatial panel data models has gained increasing prominence in recent years.

4. Results and Discussions

In this study, the results of the Ordinary Least Squares (OLS) regression without accounting for spatial effects are also reported. The OLS approach, with its well-established properties of being Best, Linear, and Unbiased (BLUE), provides a fundamental benchmark against which more complex models can be evaluated. In this context, the findings of the OLS estimation, together with those of the Fixed Effects and Random Effects models that do not incorporate spatial dependencies, are presented.

Table 2: Estimation Results of OLS, Fixed Effects and Random Effect Models

Variables	OLS		Fixed Effects		Random Effects	
	Coefficients	Prob. Value	Coefficients	Prob. Value	Coefficients	Prob. Value
Intar	0.083	(0.00)***	-0.014	(0.61)	0.017	(0.51)
Intech	0.083	(0.00)***	0.001	(0.65)	0.002	(0.49)
lnhc	0.315	(0.19)	0.016	(0.29)	-0.050	(0.00)***
lninv	0.022	(0.00)***	0.022	(0.00)***	0.026	(0.00)***
lnpop	0.860	(0.00)***	0.233	(0.03)**	1.052	(0.00)***

Note: *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level. Notes: Dependent variable = GDP (gdp). OLS = Ordinary Least Squares.

Table 2 summarizes the OLS, Fixed Effects, and Random Effects estimation results. The empirical findings reveal that the vast majority of the explanatory variables included in the model exert a positive and statistically significant impact on economic growth. However, given the assumption that public investments in Turkey may exhibit spatial dependence, spatial dependence tests were conducted, the results of which are presented in Table 3.

Table 3: Spatial Effect Results

LMlag	470.68	0.00***
LMerr	36.39	0.00***
Likelihood Ratio	1164.8783 (SDM)	1002.1472 (SAR)

The findings indicate the presence of a statistically significant spatial effect at the 1% level, both in the error terms and in the dependent variable. The simultaneous identification of spatial dependence in both the error structure and the dependent variable strongly suggests the existence of pronounced spatial dependence. In this regard, the results provide support for the validity of the Spatial Durbin Model (SDM).

In addition, a likelihood ratio (LR) test was performed to compare competing model specifications. The LR test allows for the evaluation of the relative fit of two nested models, where the objective is to determine whether a more complex model provides a significantly better fit than a more parsimonious one. The null and alternative hypotheses of the test are formulated as follows:

H_0 : The simpler model is valid.

H_1 : The more complex model is valid.

In the present analysis, the simpler model corresponds to the Spatial Autoregressive Model (SAR), while the more complex specification is represented by the Spatial Durbin Model (SDM). Model selection is based on the LR test statistic, which is defined as:

$$LR = -2 \times (LL1 - LL2) \quad (6)$$

where LL1 denotes the log-likelihood of the SDM, and LL2 denotes the log-likelihood of the SAR model.

The analysis yields log-likelihood values of LL1=1164.8783 for the SDM and LL2=1002.1472 for the SAR model. Based on these values, the LR statistic is calculated as 325.4622. Since the SDM includes five additional parameters compared to the SAR model, the test is conducted with 5 degrees of freedom. At the 5% significance level, the critical chi-square value for 5 degrees of freedom is 11.071. The calculated LR statistic substantially exceeds the critical value, leading to the rejection of the null hypothesis that the SAR model is sufficient.

In conclusion, the empirical results indicate that the SDM provides a superior specification relative to the SAR model and should therefore be preferred as the more appropriate model for the dataset under investigation

Table 4: The Results of Spatial Durbin Model and Marginal Effects of Spatial Durbin Model

Variables	SDM (Main Model)	SDM (Marginal Effects)		
	Coefficient Prob. Value	Direct	Indirect	Total
lntar	0.037 (0.01)**	0.046 (0.09)*	0.108 (0.52)	0.155 (0.40)
lntech	-0.0001 (0.91)	-0.000 (0.98)	-0.002 (0.93)	-0.002 (0.93)
lnhc	0.078 (0.00)***	0.072 (0.00)	-0.107 (0.16)	-0.034 (0.66)
lninv	0.004 (0.00)***	0.010 (0.00)***	0.073 (0.00)***	0.083 (0.00)***
lnpop	0.905 (0.00)***	0.874 (0.00)***	-0.377 (0.23)	0.496 (0.15)***
Hausman: $\chi^2(5) = 14.58$ Prob>= $\chi^2 = 0.202$				
Spatial Rho: 0.811 (0.00)				

Note: *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

In the analysis of the relationship between the agricultural sector and economic growth in Turkey, following the identification of spatial dependence, the Hausman test was employed to determine whether the fixed effects or random effects specification provides a more appropriate fit. The results indicate that, once spatial dependence is accounted for, the random effects panel data model offers the best specification for explaining the relationship between agriculture and growth.

According to the model estimates, the agricultural sector variable (*lntar*) exerts a positive impact on economic growth, with a coefficient of 0.037 in the

baseline model. The results of the marginal effects analysis corroborate this finding, showing that the direct effect is positive (0.046) and statistically significant at the 10% level. This outcome suggests that agricultural activities contribute directly to local economic growth. However, while the indirect effect (0.108) and the total effect (0.155) are also positive, they do not reach the 10% significance threshold, indicating that agriculture's influence on neighboring provinces remains limited.

With respect to the technology variable (*Intech*), the findings show no statistically significant impact across the baseline model or the marginal effects decomposition. In the baseline specification, the coefficient is estimated at -0.0001 , while the direct effect (-0.000), indirect effect (-0.107), and total effect (-0.034) all lack statistical significance. These results suggest that the level of technological development does not generate a homogeneous effect on economic growth across provinces, likely reflecting regional disparities in technological capacity. This highlights the need for further research into the nuanced relationship between technology and growth in Turkey.

The results for human capital (*Inhc*) reveal a positive contribution to economic growth, with a coefficient of 0.078 in the baseline model. The marginal effects show a direct effect of 0.072, which is positive and statistically significant at the 1% level. By contrast, the indirect effect (-0.107) and total effect (-0.034) are negative and statistically insignificant. These findings indicate that human capital contributes directly to local economic growth, but its spillover effects across neighboring provinces are weak. Thus, while human capital is a critical determinant of growth, its regional diffusion effects appear limited.

The findings for public investment (*Ininv*) demonstrate a positive effect, with a coefficient of 0.004 in the baseline model. Marginal effects estimation reveals that the direct (0.010), indirect (0.073), and total (0.083) effects are all positive and statistically significant at the 1% level. This result underscores the strong role of public investment in driving economic growth both locally and spatially, highlighting its importance as a key instrument in regional development policies.

Regarding the labor force variable (*lnlab*), the baseline coefficient is estimated at 0.905, indicating a strong positive influence on economic growth. The marginal effects show that the direct effect (0.874) is positive and significant at the 1% level, while the indirect (-0.377) and total (0.496) effects are statistically insignificant. These results suggest that labor constitutes a fundamental driver of growth in Turkey, but its spatial spillover effects across provinces are relatively weak.

Finally, the spatial dependence parameter rho (ρ) is estimated at 0.811 and is statistically significant at the 1% level. This finding provides clear evidence of spatial dependence in economic activity across Turkish provinces, indicating that economic developments in a given province tend to generate positive spillovers into neighboring regions.

Conclusion and Policy Implications

This study has examined the relationship between the agricultural sector and economic growth in Turkey using panel data methods that account for spatial dependence. The analysis first confirmed the presence of spatial interactions, after which the Hausman test was applied to determine the appropriate model specification. The results indicated that the random effects panel data model provided the most suitable framework once spatial dependence was incorporated. The findings show that the agricultural sector exerts a positive effect on economic growth in both the baseline model and the marginal effects analysis. In particular, the direct effect was found to be positive and statistically significant at the 10% level, suggesting that agricultural activities stimulate local economic growth in the regions where they occur. By contrast, the indirect and total effects were statistically insignificant, indicating that the spillover effects of agricultural production on neighboring provinces remain limited.

The analysis further revealed that the level of technology does not exert a statistically significant influence on economic growth through either direct or indirect channels. This outcome implies that interprovincial disparities in

technological capacity prevent the emergence of a homogeneous growth dynamic and points to the need for more detailed investigation of the technology–growth nexus in Turkey. Human capital, on the other hand, was found to positively and significantly affect economic growth at the local level, while showing no significant effect in spatial terms. This result underscores the critical role of human capital as a determinant of economic growth in Turkey but also highlights the weakness of its diffusion mechanisms across regions.

Public investment emerged as a key driver of growth, exerting strong and statistically significant effects at both the local and spatial levels. This finding suggests that public investments not only support growth within the province in which they are made but also generate positive spillovers into neighboring provinces. With respect to the labor force, the results demonstrate that the direct effect is strong and positive, confirming labor as one of the fundamental determinants of economic growth in Turkey. However, the insignificance of the indirect and total effects indicates that the spillover impact of labor across regional labor markets remains limited. Finally, the rho (ρ) coefficient representing spatial dependence was found to be both high and statistically significant, demonstrating strong spatial interdependence in economic activity across provinces. This finding highlights that economic developments in one province extend beyond local boundaries to influence neighboring regions as well.

The results also confirm that the direct effect of labor on economic growth is significant and positive. This underscores the role of labor supply as one of the key drivers of Turkey’s growth process. At the same time, the limited indirect and total effects suggest structural mismatches in regional labor markets. Accordingly, policies aimed at fostering regional labor mobility, expanding employment capacity, and strengthening infrastructure and housing policies that facilitate spatial integration of the workforce are critical to achieving more inclusive and balanced growth.

The findings further demonstrate that the direct, indirect, and total effects of technology are statistically insignificant. As emphasized in endogenous growth theory, R&D investment and innovation are fundamental drivers of long-run growth. However, regional disparities in the distribution of technological investment in Turkey appear to constrain the potential contribution of technology to growth. In this regard, redesigning technology policies to reduce regional disparities, strengthening mechanisms for interprovincial technology transfer, and extending innovation ecosystems beyond major metropolitan areas to mid-sized production centers are of critical importance.

Another important result concerns human capital. The finding that human capital significantly affects growth at the provincial level confirms the relevance of knowledge and skill accumulation as predicted by endogenous growth models. Nevertheless, the limited spatial effects of human capital call for a restructuring of education and labor market policies to address regional disparities. Strengthening university–industry collaborations, enhancing the adaptability of regional labor markets, and expanding vocational training and skill development programs would increase the contribution of human capital to growth.

The strong and significant direct, indirect, and total effects of public investment are consistent with the Keynesian demand-side policy framework. Infrastructure investments, particularly in transportation and logistics networks, strengthen interprovincial production linkages and accelerate growth through spatial externalities. Thus, prioritizing regional needs in public investment allocation and channeling resources toward productive infrastructure in lagging regions would contribute to more balanced and sustainable growth.

Finally, the positive contribution of the agricultural sector to local economic growth is noteworthy. Agriculture is not only a primary production activity but also a strategic sector that provides essential inputs to both industry and services. For this reason, enhancing agricultural productivity through technological adaptation,

modern irrigation techniques, and agricultural R&D investment is crucial for sustaining long-run economic growth.

Taken together, the findings suggest that agriculture and public investment are key drivers of economic growth in Turkey; human capital is an important determinant at the local level though with limited spatial spillovers; and technology does not generate homogeneous growth effects across provinces. Against this background, regional development policies should strategically support agriculture and public investment, strengthen the spatial diffusion channels of human capital, and promote technological progress in ways that reduce regional disparities. These represent critical policy areas for fostering more balanced and sustainable growth.

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