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The Role of Regional Electricity Consumption on Regional Development in Türkiye

Türkiye'de Bölgesel Elektrik Tüketiminin Bölgesel Kalkınma Üzerindeki Rolü

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Abstract
Electricity consumption is an essential element of economic activities and economic development. For countries such as Türkiye, which is a country in the development process, it is necessary to understand the effect of electricity consumption on macro indicators such as growth and development. This is because electricity consumption is the driving force in sectors such as agriculture, industry and the service sector and is essential for the Turkish economy. This study analyses the relationship between sectoral electricity consumption of 81 provinces of Türkiye and GDP per capita, one of the development indicators, for 2013-2021. In addition, exports and imports are used as control variables. The study aims to better understand the regional economic effect of electricity consumption on development. The method used in the study is spatial panel data econometrics. In addition, Moran's I statistics are also utilised. These methods reveal the mutual interactions between neighbouring units (provinces) for Türkiye. Among the findings of the study, electricity consumption in government offices per capita and electricity consumption in agricultural irrigation per capita negatively affect GDP per capita. In contrast, electricity consumption in industry per capita positively affects GDP. This study provides findings that will increase the effectiveness of energy policies and regional development plans to be implemented in Türkiye.
Keywords: Türkiye, Electricity Consumption, Spatial Panel Econometrics, Moran's I, Regional Development

Öz
Elektrik tüketimi, iktisadi uygulamaların ve iktisadi gelişmenin önemli bir unsurudur. Gelişme sürecinde bir ülke olan Türkiye gibi ülkeler için elektrik tüketim göstergesinden faydalanılarak büyüme ve kalkınma gibi makro göstergelere etkisini anlamak oldukça elzemdir. Zira tarım, sanayi ve hizmet sektörü gibi sektörlerde elektrik tüketimi itici güçtür ve Türkiye ekonomisi için önemlidir. Bu çalışmada 2013 - 2021 döneminde Türkiye'nin 81 ilinin sektörel elektrik tüketimi ile kalkınmanın göstergelerinden biri olan kişi başına düşen GSYH arasındaki ilişki analiz edilmektedir. Buna ek olarak ihracat ve ithalat kontrol değişkenleridir. Çalışmada elektrik tüketiminin kalkınmada bölgesel ekonomik etkisini daha iyi anlamak amaçlanmaktadır. Çalışmada kullanılan yöntem, mekânsal panel veri ekonometrisidir. Buna ek olarak Moran's I istatistiklerinden de faydalanılmıştır. Bu yöntemlerle komşuluk ilişkisi bulunan birimler (iller) arasındaki karşılıklı etkileşimler Türkiye özelinde ortaya konulmuştur. Kişi başına resmi dairelerdeki elektrik tüketimi ile kişi başına tarımsal sulamadaki elektrik tüketiminin kişi başı GSYH'yi negatif etkilediği; kişi başına düşen sanayide elektrik tüketiminin ise pozitif etkilediği çalışmanın bulguları arasında yer almaktadır. Bu araştırma Türkiye'de uygulanacak olan enerji politikaları ve bölgesel kalkınma planları için etkinliği arttıracak bulgular sunmaktadır.
Anahtar Kelimeler: Türkiye, Elektrik Tüketimi, Mekânsal Panel Ekonometrisi, Moran's I, Bölgesel Kalkınma

Introduction

Energy is among the most important factors in the development stages of developing countries such as Türkiye and in ensuring the growth of developed countries, and individuals need energy to meet their needs (Çınar, Yetkin, & Bektaş, 2019: 346). In addition to emphasizing the importance of energy, since it has become increasingly important to use electricity efficiently in a country's economy, energy efficiency is the subject of energy policies and socio-economic development (Kott, 2015: 54). The increase in electricity consumption is a factor that causes the economic development of countries. Therefore, the effects of electricity consumption stand out as a topic worthy of research for both researchers and politicians (Çadırcı & Güner, 2020: 41). In this context, issues such as electricity consumption and energy efficiency are issues that are fundamental to development.

There are several differences between regions. These differences can manifest themselves physically and socially and affect the development levels of regions. Regional development is a very important phenomenon for the development of the economic and social structure in various regions and for increasing the level of welfare (Tekin, 2015). However, with the increase in the differences in the development levels of the regions, inequality in income distribution, poverty and some socio-economic problems may occur. These problems point to major negativities in the development process of the country (Yılmaz, 2023: 17). At this point, some issues are taken into account in regional policies, among which regional differences and development levels of regions are among the most important ones. Accordingly, regional disparities are an issue that concerns both underdeveloped countries and developed countries (Gorun & Emini, 2010: 422), because economic development in a country never starts simultaneously in the whole country. Privileged regions develop first and progress is gradually concentrated in those regions. Therefore, a country that wants to develop will necessarily experience socio-economic differences between regions (Dinler, 2016: 134-135). In this respect, as a requirement of a country's welfare state understanding, imbalances should be eliminated and differences between rich and poor regions should be eliminated, etc. (Üncü, Abanoz, Ölmez, Durukan, Söylemez, Zoral, Özel, Akbay, & İnce, 2008: 9).

Regional disparities are a major problem worldwide. After the 1950s, studies have been carried out to eliminate this problem (Özkubat and Selim, 2019: 450). In this regard, it can be stated that one of the main objectives of development plans is to reduce the development gap between regions (OKA KSP, 2019: 8 - 9). In the process of determining regional policies, many factors such as socio-economic conditions, energy consumption differences, imbalances, etc. between regions should be evaluated together. At this point, it is possible to make evaluations with factors such as electricity consumption indicators of the regions, economic growth data, indexes, statistical analysis findings, efficiency measurements and spatial analysis results.

The Spatial Strategy Plan (SSP) relates socio-economic and environmental policies and strategies to space. In addition to this, the SSP provides direction on physical development and sectoral decisions and is a plan prepared both for Türkiye as a whole and for the required regions of the country. With the SSP, activities that will provide advantages by revealing the spatial potential of the country are carried out towards and within the context of Türkiye's economic development and economic growth targets (ÇŞİDB, 2024). Regarding the spatial potential of the country, attention should be paid to the importance of energy. In this context; energy is a compulsory need in terms of its contribution to production and this need is increasing (Karabağ, Çobanoğlu & Öngen, 2021: 231). At this point, the phenomenon of energy efficiency comes to the fore. Since activities related to energy efficiency are related to securing the future of the country, it is pointed out that this is a strategic element (ETKB EVSİP, 2020: 5).

Since energy is a necessity and regional development policies aim to reduce disparities, it is very important to investigate issues such as "energy consumption, energy efficiency, the impact of energy on development". In addition, development agencies, energy efficiency action plans and regional projects (GAP, DAP, etc.) are also very important in regional development and reducing regional disparities. This study is important in terms of contributing to the design of Türkiye's spatial strategy plan through the evaluations made by utilizing spatial analysis techniques and regional economics information and in terms of providing implications for institutions engaged in energy efficiency activities.

There are very few studies in the literature on the relationship between sectoral electricity consumption and economic growth (Dash, Jena, Tiwari and Hammoudeh, 2022: 3). The subject of the study is formed by taking into account the view that the electricity consumption of the regions will affect the development level of the region. In this context, especially sectoral electricity consumption is very important for the provinces of a developing country like Türkiye. That is because there are some reasons to consider sectoral electricity consumption. These reasons include the importance of understanding which sectors are concentrated in which regions, determining which sectors should be emphasized in which regions, providing a source of information in determining regional development strategies, the importance of regional electricity consumption in balancing regional energy supply and demand, etc. Moreover, to understand the detailed impact of electricity consumption on regional development, it is more useful to investigate the impact of sectoral electricity consumption than the impact of total electricity consumption. The imbalance between regions in Türkiye is seen as a problem. Based on this important problem, this study focuses on the effects of electricity consumption of each province of Türkiye on themselves and their neighbours. This study aims to reveal the effects of sectoral electricity consumption used in government offices, in industry and in agricultural irrigation etc. on regional development. In this context, this study is unique in the literature in that it deals with the relationship between energy consumption and GDP per capita based on 81 provinces and through spatial panel data econometrics. The hypothesis of the study is based on the assumption that each province's sectoral electricity consumption affects both itself and its neighbouring provinces. The keywords addressed in this study are GDP per capita, electricity consumption in government offices, electricity consumption in industry, electricity consumption in agricultural irrigation, spatial effect, and regional similarities and differences. This study consists of an introduction, literature review, data, methodology and conclusion.

2. Literature Review

Starting with the global oil crisis in the 1970s, research on the impact of energy consumption on macro-economic indicators has increased, and newly emerging econometric methods have a share in this increase (Polat, Uslu and San, 2011: 350). GDP per capita is a frequently used indicator of development in the economies (Yanar, 2014: 10). In addition, The increase in electrical energy consumption is an important indicator, especially in the development of the industrial sector, the increase in a country's per capita income and the increase in its economic welfare (Bal, Patra and Mohanty, 2022: 2). In this context, it is important to investigate the relationship between electricity consumption and regional development/development with many methods in the literature and new analysis methods increasing thanks to the developing technology. Due to this importance, it is clear that it will continue to be the subject of research. Table 1. shows the review of the literature.

Table 1. The Review of Literature on the Impact of Electricity Consumption on Economic Development

Author(s)	Country, Period	Method	Results
Ferguson et al. (2000)	More than 100 countries, 1960- 1995 and 1971-1995	Correlation Analysis	On the whole and for the global economy as a specific case, it was found that there was a stronger correlation between electricity use and wealth creation than the correlation between total energy use and wealth.
Ağır & Kar (2010)	Türkiye's 81 provinces, year 2000.	Cross-Section Regression Analysis	Based on 81 provinces in Türkiye, it was concluded that electricity consumption positively affects income.
Fei, Dong, Xue, Liang & Yang (2011)	30 provinces in China (1985-2007)	Panel Cointegration Test, Panel Econometric Methods Based on Dynamic OLS	It shows that there is a positive and long-run cointegrated relationship between real GDP per capita and energy consumption.
Aslan, Arı & Zeren (2013)	Türkiye NUTS- 3 Regions, year 2000	Geographic Weighted Regression	It was concluded that electricity consumption positively affects economic development at local and global level..
Usta (2016)	Türkiye NUTS- 2	Panel Regression	It was found that there is a positive directional relationship between total electricity

	Regions, 2004-2011	Analysis	consumption and value-added in İBBS-2 regions. A 1% increase in total electricity consumption increases the value added by approximately 0.38%.
Pata & Terzi (2017)	Türkiye, 1960-2014	ARDL	There is a positive, unidirectional causality from net electricity consumption to economic growth in both the short and long run. The increase in net electricity consumption has a positive effect on economic growth in both the short and long run.
Vardar (2017)	More than 130 countries, 2010-2014	Nonparametric Statistical Methods	It was found that there was a very high correlation between electricity consumption and the human development index (HDI).
Pata & Kahveci (2018)	Türkiye, 1978-2013	ARDL	It was concluded that there was a co-integration between electricity consumption, employment, capital stock and gross domestic product. Moreover, a positive and unidirectional causality was found from electricity consumption, gross capital stock and employment to GDP in the short and long run.
Çınar et al. (2019)	Türkiye, 1970-2017	ARDL, Toda-Yamamoto	It was concluded that there was a long-run relationship between development and electricity consumption. Moreover, it was concluded that there was a causality from electricity consumption to development.
Akomolafe (2019)	Nigeria, 1981-2014	VECM	In the long run, there is causality from the manufacturing sector to electricity consumption, but a bidirectional causality was found in the short run. It was found that there was a causality from electricity consumption to services sector output in the long run and there was a causality from electricity consumption to services sector output in the long run. It was concluded that there was no short-run causality relationship between electricity consumption and service sector and agricultural sector outputs.
Karagöl, Gorus & Özgür (2019)	Türkiye's NUTS-1 Regions, 2007- 2017	Panel Granger Causality Test	It shows that there is no causality relationship between electricity consumption and current national income.
Recepoğlu, Doğanay & Değer (2020)	Türkiye's 81 province, 2004-2014	Panel Westerlund Cointegration Testi, Panel Granger Causality Tests	Electricity consumption and economic growth variables are co-integrated in the long-run. A bidirectional causality relationship was found between electricity consumption and economic growth and it was revealed that energy input was an important factor in terms of economic growth

			and development at the provincial level in Türkiye both in the short and long run.
Song, Zhang & Li (2022)	30 Provinces in China, 2000-2019	Panel VAR	Electricity consumption only has a direct impact on economic development, while its impact on the other three variables (industrial structure upgrading, urbanization, urban-rural income gap) is transmitted through economic development. Electricity consumption first prevents and then promotes the rise of the industrial structure and electricity consumption also prevents the urban-rural income gap.
Xin-gang & Jin (2022)	30 provinces in China, 2000-2018	Panel Granger Causality, FMOLS	The impact of natural gas and renewable energy consumption on economic growth is much smaller than the impact of coal and electricity consumption. Therefore, they suggest that energy policy should encourage the development of clean energy.
Vurur (2022)	Türkiye, 1980--2020	ARDL, Toda Yamamoto, FMOLS	Under structural breaks, it is found that there is a long-run relationship between financial development, economic growth, urbanization and energy consumption.
Shameem, Villanthenkodathb & Chittedi (2022)	India, 1971-2019	Bayer- Hanck Combined Cointegration, FMOLS, DOLS and CCR, Breitung–Candelon frequency-domain causality test	The estimated results show that electricity consumption in the agricultural sector has a negative impact on real GDPPC, while electricity consumption in the industrial and service sectors increases the real GDPPC.
Lan & Cong (2023)	Vietnam, 1986-2020	ARDL	Electricity consumption positively impacts Vietnam's economic growth in the long run.
Kazanasmaz, Demirel, Karatepe & Hızarcı (2023)	Türkiye, 1967-2017	VECM, Granger and Johansen Cointegration Tests	In the long run, electricity consumption positively impacts economic growth in Türkiye. The results of the Granger causality analysis indicate that there is a unidirectional causality relationship from electricity consumption to economic growth and carbon dioxide emissions.
Suryanto, Gravitian, Diswandi & Arintoko (2023)	38 Countries, 2012-2019	PVECM	There is no empirical evidence of a long-term relationship between the level of electricity consumption, human quality of life, level of happiness and labor force.

The literature review of the studies on the relationship between electricity consumption (energy consumption) and development, regional development and regional progress is shown in Table 1. According to this table, there is mostly a causality relationship, short-run relationship and long-run relationship between energy consumption and development indicators. It is noteworthy that there are few studies where causality is not detected. In addition, the number of studies using spatial econometric methods is quite limited. This study is unique as it focuses on electricity consumption and regional development in 81 provinces of Türkiye.

3. Empirical Analysis

3.1. Data

In this study, the panel data set covering 81 provinces of Türkiye and the years 2013-2021 is used. The variables to be analyzed for the 81 provinces with neighbourhood relations between them are taken from the TurkStat regional statistics database. The variables used in the study are shown in Table 2.

Table 2. Variables

Variables	Description
gdppc	Gross Domestic Product Per Capita, province-wide, at current prices USD
gov	Per capita Electricity Consumption in Government Offices, province-wide, Mwh
ind	Per capita Electricity Consumption in Industry, province-wide MWh
agr	Per Capita Electricity Consumption in Agricultural Irrigation, province-wide, MWh
ex	Exports Per Capita, province-wide, USD
im	Imports Per Capita, province-wide, USD

Before proceeding with the analysis, the data set went through some steps. For electricity consumption in agricultural irrigation, 1 has been added to the entire series, including some missing observations and some observations with 0. The province-wide electricity consumption used in "government offices, industry and agricultural irrigation", and province-wide "exports and exports" data were converted into per capita data based on the population of the provinces. Then, natural logarithms of all variables were taken and included in the model.

There are reasons for choosing the variables shown in Table 2. gdppc is one of the indicators of development (Yanar, 2014: 10). Energy efficiency projects in public buildings have the goal of achieving energy savings (KABEV, 2024). The reason for choosing the gov variable is that the energy consumption of the public sector is directly related to regional infrastructure and access to public services.

Studies in the literature generally show that the industrial sector is one of the critical sectors in the economy (Akbulut, 2019). The reason for the choice of the ind variable is that there is a relationship between industrial production and economic output.

The variable agr is chosen because it is effective in agricultural production. Irrigation is critical not only for agricultural production but also for food security (Çakmak & Gökalp, 2013). ex and im are control variables because they are strong factors in explaining gdppc. Kircicek & Ozparlak (2023) prove the effect of exports and imports on economic growth.

This study examines the impact of regional and sectoral electricity consumption on regional development. In this study, gov is used to refer to the public sector, ind is used to refer to the industrial sector, and agr is used to refer to the agricultural sector. As of the period of the study, TurkStat provides data until 2021 for some of the variables subject to analysis. In addition, there are undoubtedly other factors that explain regional development, but it is very difficult to identify all factors. Hence, the spatial model is constructed by excluding other factors. Therefore, this paper is valid under certain conditions, and even if similar methods are applied outside of these conditions, interpretations will need to be made with caution.

Table 3. Descriptive Statistics

Variables	Obs.	Mean	Std. Dev.	Min.	Max.	VIF
gdppc	729	7979.834	2977.133	2871	20883	-
gov	729	0.1358127	0.0735977	0.0021427	0.6232632	1.04
ind	729	1.422995	1.588218	0.0028826	9.582769	1.17
agr	729	0.0965028	0.1811351	6.04e-06	1.707085	1.03

ex	729	0.8475964	1.143582	0.0000424	6.859838	3.87
im	729	0.7765133	1.423849	0.0000471	11.6855	4.03

Table 3 shows the descriptive statistics. Since there are 81 units (provinces) in our panel data set and each unit has different characteristics, the difference between the minimum and maximum values within the variables is high. According to Yerdelen Tatoğlu (2022), if the mean VIF value is less than 10, it means that there is no multicollinearity in the model. The VIF values for the variables and the mean VIF (2.23) indicate that there is no multicollinearity. Therefore, multivariate regression model can be estimated. The analysis was conducted using the Stata17 statistical package program.

3.2. Spatial Econometrics Method

The spatial econometric method is a method created for spatial interaction and spatial heterogeneity for cross-sectional and panel data. It differs from traditional econometric models by enabling the modeling of inter-unit relationships (Zeren, 2011). Geographically close units may have similar characteristics (Babacan & Tektaş, 2022: 40). At this point, the famous quote of Waldo Tobler (1970) may come to mind: "Everything is related to everything else, but near things are more related than distant things."

Analyses with data sets analyzed at the regional level may reveal dependence and interaction between neighbouring regions (Özmen & Baktemur, 2016). At this point, spatial panel data models may come to the fore. If the panel data set contains spatial elements, conventional models lead to biased estimates. The problem is that since panel data contains spatial factors, the parameters may not be homogeneous across space, but there may be variations in different regions (Elhorst, 2003: 244 - 245).

The estimation and testing of spatial econometric methods was first proposed by Whittle (1954). Cliff and Ord (1981) studied spatial processes and models for these processes. Anselin (1988) gave detailed information about spatial econometric models and estimation in his work titled "spatial econometrics". The relationship (i.e. interaction) between places is expressed as a "spatial effect". These effects affect the models through "spatial autocorrelation" or "spatial heterogeneity". Spatial correlation, i.e. spatial dependence, describes a special case of inter-unit correlation and is a measure of a relationship between places. Spatial heterogeneity is the same as heterogeneity in the econometrics literature. Another important concept is the "spatial weight matrix", which uses maps to explain the relationship between places. A row-standardized neighborhood matrix is called a spatial weight matrix. Each element w_{ij}^* of this matrix can be obtained as shown in equation 1 as follows;

$$w_{ij}^* = \frac{w_{ij}}{\sum_{j=1}^{N} wij} \quad (1)$$

Spatial interaction or spatial dependence can generally be described by a spatial weight matrix (denoted by W). Wy denotes the average spatial weight of y in neighbouring regions. The spatial weight matrix W, which is also constructed based on the geographical arrangement or proximity of observations, has dimension n x n (Gumprecht, 2005: 2). For panel data, the neighbourhood matrix W is a positive matrix of size NT x NT, where each element (Wij) represents the interaction between regions i and j. Simply, the neighborhood matrix takes one of two values; 1 if regions i and j are neighbors and 0 if they are not. Weighting can be done according to the neighbourhood relationship as well as weighting according to the distance. (Yerdelen Tatoğlu, 2023: 286-287) n can be expressed as the number of geographical units (states, provinces, etc.). Each element of this matrix (Wij) describes the neighbourhood of the elements in the row and column. Neighbourhood matrices can be related to the common border commonality of locations or can be determined by the distance between locations. In addition, spatial dependence is modelled as a "spatial lagged process" and "spatial error process" (Zeren and Kılınç Savrul, 2012):

- In the Spatial Lagged Process: there is a spatially lagged dependent variable and it is included among the control variables. This model is as in equation 2;

$$y_i = \rho W_{y_i} + \beta x_i + u_i , \qquad u_i \sim N(0, \sigma_u^2) \quad (2)$$

W_y refers to the dependent variable in neighbouring regions. The parameter ρ represents the spatial interaction between regions in terms of the dependent variable and is an autoregressive parameter.

- In the Spatial Error Process: in the presence of a spatial error model, spatial dependence is generated by the residuals of the regression model and is expressed as in equation 3:

$$y_i = \beta x_i + u_i$$
$$u_i = \lambda W_{u_i} + \varepsilon_i, \qquad \varepsilon_i \sim N(0, \sigma_\varepsilon^2) \quad (3)$$

The parameter λ is the spatial autoregressive parameter for the error process. Since the final model in this study is the SDEM model, the spatial error process is taken into account.

Compared to basic panel data models, spatial panel data models allow for spatial dependence and spatial spillover effects. In addition, when cross-sectional spatial model is compared with spatial panel data model, spatial panel data model can better account for the heterogeneity of units and reduce estimation errors considerably (Elhorst, 2014). When spatial correlation is detected, least squares estimation may be biased and therefore appropriate spatial econometric estimators may be required (Rey & Montouri 2000; Le Gallo, Ertur & Baoumont 2003; Arbia, Basile & Piras 2005). In this context, Anselin (1988) emphasizes that one of the appropriate estimators is the maximum likelihood (ML) method.

Since this study analyzes regional and neighboring units, there may be spatial dependence between observations. Gültekin & Oğuzhan (2021) argue that not taking this dependency into account may lead to inaccurate estimation results. Moreover, Yılgör (2019) states that the spatial neighborhood relations of regions should be examined before estimating spatial models. This relationship can be obtained with Moran's I statistics. Therefore, this study utilizes Moran's I statistics and spatial panel regression models.

3.3. Moran's I Test

Spatial autocorrelation test gives positive or negative autocorrelation (Yılgör, 2019: 65). The most commonly used method to test for spatial autocorrelation is the "Moran's I" statistic for regression residuals, which was developed by Moran (1948), Moran (1950a) and Moran (1950b). This test statistic for spatial dependence is explained as follows (here eq. 4) (Anselin, 1998; Gumprecht, 2005; Lesage, 1999):

$$I = \frac{e'We}{e'e} \tag{4}$$

In this test statistic, W stands for the spatial weight matrix. . $e = y - X\beta$, is the n x 1 vector of errors from the least squares (LS) estimation of the regression model. e'e is the sum of squares of the residuals (Cliff and Ord, 1972). A positive Moran's I coefficient indicates a positive spatial autocorrelation while a negative coefficient indicates a negative autocorrelation. The hypotheses in the Moran's I test are as follows (Yılgör, 2019);

H_0: There is no spatial correlation between observations at the spaces.

H_1: There is a spatial correlation between observations at the spaces.

Moran's I test can have different representations. An example of this is the following: (eq. 5.):

$$I = \frac{R}{\sum_i \sum_j W_{ij}} = \frac{\sum_i \sum_j W_{ij}\,(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})} \tag{5}$$

x: the analyzed variable. R: number of regions. $\bar{x}$: x's cross-sectional mean. W: spatial weight matrix (Yılgör, 2019).

There is also a test that looks at Local spatial autocorrelation. This test is Local Moran's I (LISA) test. This statistics derived by Anselin (1995), shows the relationship of each region with its neighbors. The presence of spatial dependence in general is assessed with the Global Moran's I test, while the presence of regional correlations is assessed with the Local Moran's I test (Yerdelen Tatoğlu, 2022: 121). Figure 1[1] shows the template of a scatter plot diagram that can be created after the Moran's I test.

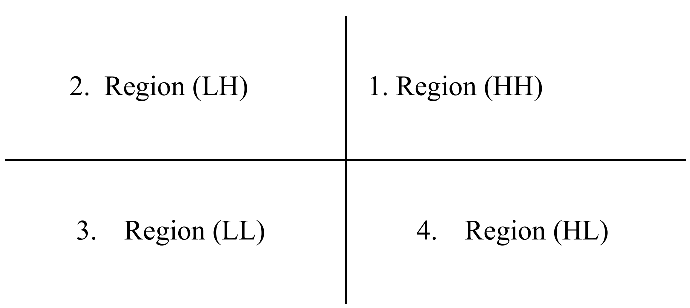

Figure 1. The Template of a Scatter Plot Diagram for Spatial Relationship

In this study, global and local Moran's I statistics are presented. Then, model specification tests are conducted and the

[1] In the figure; HH refers to High High Region, LH refers to Low High Region, LL refers to Low Low Region, and HL refers to High Low Zone.

appropriate model is presented.

3.4. Spatial Regression Models

Spatial econometric techniques have also been developed for panel data sets since the 2000s, when the units in the panel data set are locations, regions, provinces, etc. Spatial effects are included in spatial econometric models in three ways: Interaction with the dependent variable (Y), interaction with independent variables (X) and interaction with the error term (u). A spatial effect in the dependent variable is a spatial lag model. A spatial effect in the independent variables is a spatial lag X model, and finally, a spatial effect in the error term is a spatial error model. Two or three of these effects may occur simultaneously. The equations of these econometric model types are as follows (Yerdelen Tatoğlu, 2023);

General Nested Model (GNS): $Y = \rho WY + X\beta + WX\theta + u, \quad u = \lambda Wu + \varepsilon$

Spatial Durbin Model (SDM): $Y = \rho WY + X\beta + WX\theta + \varepsilon$

Spatial Autoregressive Combined Model (SAC): $Y = \rho WY + X\beta + u, \quad u = \lambda Wu + \varepsilon$

Spatial Durbin Error Model (SDEM): $Y = X\beta + WX\theta + u, \quad u = \lambda Wu + \varepsilon$

Spatial Autoregression Model (SAR): $Y = \rho WY + X\beta + \varepsilon$

Spatial Error Modeli (SEM): $Y = X\beta + u, \quad u = \lambda Wu + \varepsilon$

Spatial Lag of X Model (SLX): $Y = X\beta + WX\theta + \varepsilon$

Model without Spatial Effects: $Y = X\beta + u$

There are many tests in the literature for selecting the most appropriate model. Spatial dependence tests (LM tests), spatial autocorrelation tests (LR tests), whether the model contains unit effects or not, and if it contains unit effects, Hausman test for the selection of the model with fixed effects or random effects, etc. tests are used (Yılgör, 2019; Yerdelen Tatoğlu, 2023).

3.5. Maximum Likelihood Estimation

There are various estimators in spatial panel data models. Among these estimators, the maximum likelihood method is the most widely used (Anselin, 1988). The assumptions and equations of this method are as follows (Yerdelen Tatoğlu, 2023):

The assumption of the normal distribution of the residual for the SEM model is the following: $\varepsilon \sim N(0, \Omega_{NT})$. With this assumption, the log likelihood function is constructed (equation 6):

$$L = -\frac{NT}{2} ln\sigma_\varepsilon^2 + T\ln|B_N| - \frac{(y-X\beta)'[I_T \otimes (B_N' B_N)](y-X\beta)}{2\sigma_\epsilon^2} \quad (6)$$

Over here**;**

$$\Omega_{NT} = E[\varepsilon_t \varepsilon_t'] = \sigma_\varepsilon^2 (I_N - \lambda W_N)^{-1} (I_N - \lambda W_N')^{-1}$$

The NTxNT dimensional variance covariance matrix (Ω_{NT}) and its inverse are respectively as follows;

$$\Omega_{NT} = \sigma_\varepsilon^2 [I_T \otimes (B_N' B_N)^{-1}]$$

$$\Omega_{NT}^{-1} = \frac{1}{\sigma_\varepsilon^2} [I_T \otimes (B_N' B_N)]$$

This study uses the maximum likelihood method for estimation of spatial econometric models. Indeed, Elhorst (2005) argues that the maximum likelihood method (MLE) is most commonly used for the spatial panel.

3.6. Empirical Results

With the help of the Stata17 statistical package program used in the study, maps of cross-sectional units and Moran's I statistics can be created for each year. Figure 2, Figure 3, Figure 4 and Figure 5 show the cross-sectional maps of the main variables for 2021. By reviewing the maps of the variables, it is possible to identify regional clusters and regional differences.

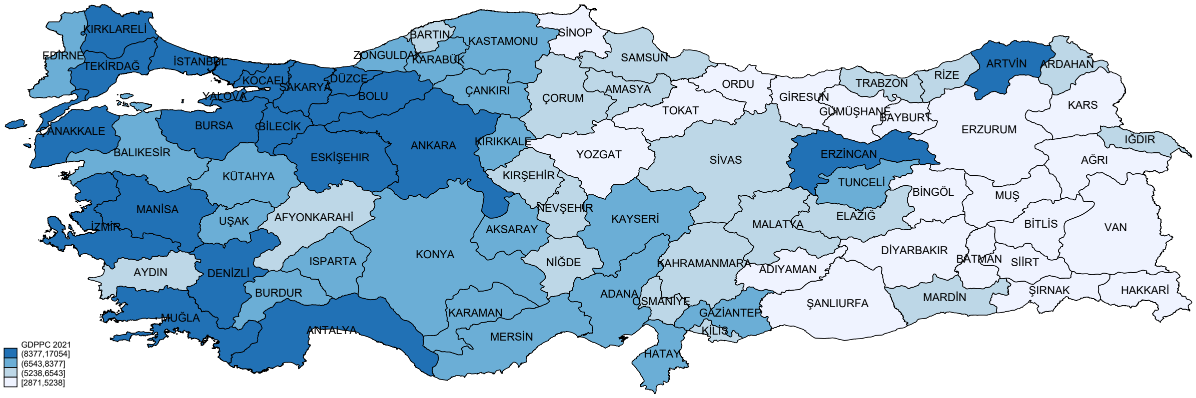

Figure 2. Province-wide gdppc in 2021 (USD)

According to Figure 2, the gdppc of provinces is quite low in the eastern region of Türkiye in 2021. However, gdppc increases towards the west of the country. This distribution is a clear indication that there are some regional differences in the country. However, Erzincan and Artvin, which are located in the east of the country, differ from neighbouring provinces in a sense. Similarly, although Afyonkarahisar province is located in the west, it differs from its neighbours.

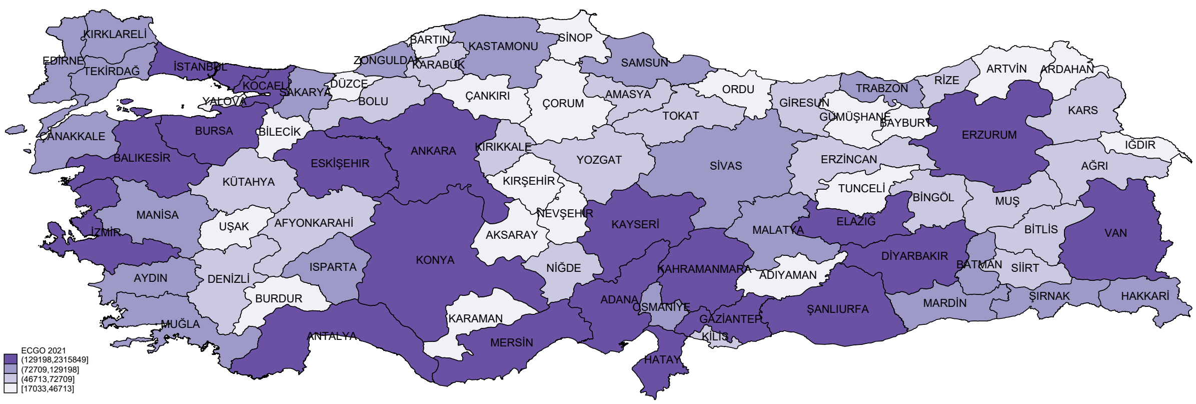

Figure 3. Province-wide Electricity Consumption in Government Offices in 2021 (MWh)

According to Figure 3, electricity consumption in government offices (gov) is higher in Türkiye's developed metropolises such as Istanbul, Ankara, Izmir, etc.,in regional centers such as Erzurum, Van etc., while it is considerably lower in smaller and relatively less developed cities. In this context, it can be observed that the intensity of electricity consumption in public offices is not homogenously distributed regionally in the country.

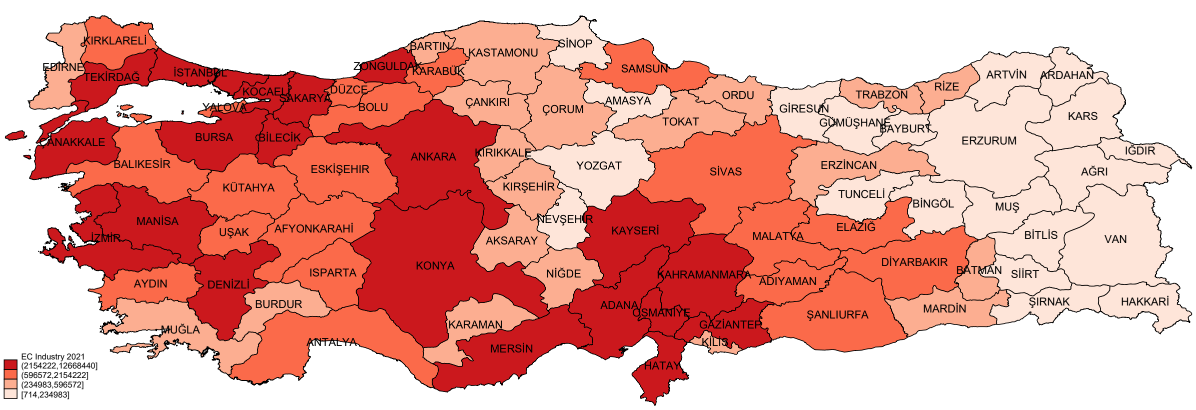

Figure 4. Province-wide Electricity Consumption in Industry in 2021, (MWh)

The similarity of Figure 4 with Figure 2 is striking. According to the Figure 4, electricity use in industry (ind) is quite low in the eastern provinces. However, similar to gdppc, ind increases for western provinces. This similarity may reveal that there may be a correlation relationship between electricity consumption in industry and gdppc.

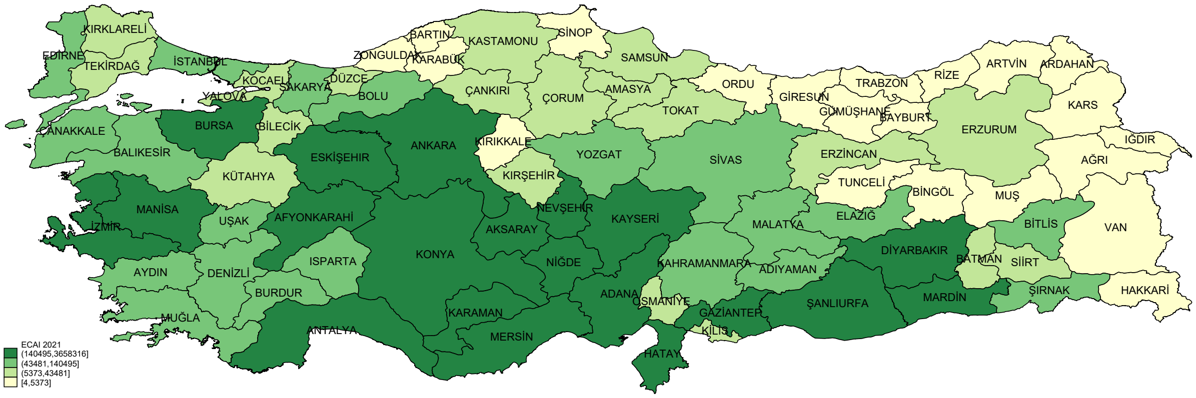

Figure 5. Electricity Consumption in Agricultural Irrigation in 2021, (MWh)

According to the Figure 5, electricity consumption for agricultural irrigation (agr) in 81 provinces of Türkiye is more intense in the south and west regions compared to the east and northeast regions. Since Türkiye is located in a belt with 4 seasons and is a peninsula country, agricultural product diversity is high. Due to these geographical characteristics, regional heterogeneity can be expected in the country, but also it is noticeable that there are regional clusters. In this context, agr is particularly high in provinces located in areas favourable to agriculture and similar climates.

Spatial distributions are shown with maps, clusters, etc. It is possible to explain them with Moran's I statistics. At this point, the existence of spatial autocorrelation can be tested with the help of Global Moran's I statistics and Local Moran's I statistics. Test statistics and p values are shown in the tables.

Table 4. Global Moran's I Statistics

Years	gdppc	gov	ind	agr
2013	0.633 (0.0000)*	-0.004 (0.8876)	0.316 (0.0000)*	0.401 (0.0000)*
2014	0.680 (0.0000)*	-0.022 (0.8637)	0.315 (0.0000)*	0.428 (0.0000)*
2015	0.703 (0.0000)*	-0.021 (0.8627)	0.342 (0.0000)*	0.256 (0.0000)*
2016	0.701 (0.0000)*	-0.008 (0.9464)	0.328 (0.0000)*	0.262 (0.0000)*
2017	0.681 (0.0000)*	0.003 (0.7732)	0.347 (0.0000)*	0.262 (0.0000)*
2018	0.683 (0.0000)*	-0.010 (0.9770)	0.317 (0.0000)*	0.191 (0.0003)*
2019	0.667 (0.0000)*	-0.013 (0.9908)	0.322 (0.0000)*	0.216 (0.0000)*
2020	0.651 (0.0000)*	-0.004 (0.8875)	0.335 (0.0000)*	0.207 (0.0000)*
2021	0.660 (0.0000)*	-0.004 (0.8937)	0.341 (0.0000)*	0.192 (0.0000)*

Note: * significant at 0.05.

Global Moran I statistics of 4 variables are given together according to the years in the table. Except for the gov series, the other variables are significant for each year in the period 2013-2021. In addition, all significant I statistics are positively correlated. The Global Moran's I statistics of GDPPC remain positively correlated in the range of 63% - 70%, while those of ind remain in the range of 31% - 34%. However, agr's Global Moran's I statistics have been on a downward trend since 2013-2014. In this context, it is seen that the positive correlation of Türkiye's cities with their neighbouring cities for the agr variable has been decreasing over time.

Table 5. The Results of Local Moran's I Statistics in 2021

Quadrant	gdppc	gov	ind	agr
1st (HH)	Bilecik, Bolu, Bursa, Çanakkale, Eskişehir, İstanbul, Kırklareli,	-	Bursa, Hatay, İstanbul, Kocaeli, Osmaniye, Tekirdağ	Diyarbakır, Konya, Mardin, Şanlıurfa,

	Kocaeli, Tekirdağ, Yalova			
2nd (LH)	-	-	-	-
3rd (LL)	Ağrı, Batman, Bitlis, Diyarbakır, Kars, Muş, Şanlıurfa, Siirt, Van	-	-	-
4th (HL)	-	Ankara	-	-

Note: Significant results according to 0.05 are given in the table.

Table 5 shows LISA results. Accordingly, it is clear that there are clusters in terms of provinces belonging to HH and LL regions, which express a positive correlation in gdppc in Türkiye. Especially in the HH region, which includes Istanbul, Bursa and Kocaeli, it is seen that while gdppc is high in themselves, gdppc is high in the neighbouring provinces. On the other hand, for the gdppc variable in the eastern part of Türkiye, the provinces in the LL region have low gdppc in themselves and low gdppc in their neighbouring provinces. Similarly, it is possible to see regional clustering in ind and agr variables. In contrast to these, Ankara, the capital of the country, is in HL, which is one of the negative correlation regions (2nd and 4th) in the gov variable. In short, while gov is high in Ankara, gov is low in the provinces surrounding Ankara.

3.7. Model Selection

It has been proved that spatial effect can be added to panel data models (Elhorst, 2003). At this point, several tests are performed when choosing the appropriate model. The SAC model, which is one of the general models, can be established and the presence of unit effect in the model can be examined by LM tests. Baltagi and Liu (2008) introduced the LM test for panel data regressions, which simultaneously tests for spatial lag dependence and the absence of random unit effect. Based on Gülel (2013), interpretations can be made with the generalisation that the H_0 hypotheses of LM tests are 'no autocorrelation (no unit effect)'. In this study, the LM test results obtained by utilising the classical SAC model are shown in the table.

Table 6. The Results of LM Tests

Tests	Stats	Prob.
Breusch-Pagan LM Test -Two Side	1637.33	0.0000*
Breusch-Pagan ALM Test -Two Side	973.03	0.0000*
Sosa-Escudero-Yoon LM Test -One Side	40.46	0.0000*
Sosa-Escudero-Yoon ALM Test -One Side	31.19	0.0000*
Baltagi-Li LM Autocorrelation Test	755.10	0.0000*
Baltagi-Li ALM Autocorrelation Test	90.81	0.0000*
Baltagi-Li LM AR(1) Joint Test	1728.14	0.0000*

According to these results, the H_0 hypothesis is rejected at 0.05 significance level. There is a unit effect in our model. Hausman test allows the decision to use the correct model in terms of obtaining consistent estimates (Baltagi, 2008). Accordingly, the Hausman test is used to determine the final model. It can be decided whether to estimate the model with fixed effects (FE) or random effects (RE). The test proposed by Hausman (1978) is used for the choice between the two models. H_0: Fixed effects and random effects model are consistent, random effects model is efficient. H_a: fixed effects model is consistent, random effects model is inconsistent. Hausman LM Test result:

- Hausman LM Test = 0.03445 P-Value > Chi2(6) (1.0000)

According to this test result, H_0 cannot be rejected. Therefore, the random effects (RE) model is efficient. After that, the spatial effect can be tested. With the SAR model, which is one of the general models, the test results of the spatial effect are tested by considering the random effects (RE). Table 7. shows the test results for spatial effect.

Table 7. The Tests for Spatial Effect

H_o: Error has no spatial autocorrelation		
H_a: Error has spatial autocorrelation		
Tests Stats Prob.		
GLOBAL Moran MI	-0.2047	(0.0000)
GLOBAL Geary GC	1.1294	(0.0002)
GLOBAL Getis-Ords GO	1.0060	(0.0000)
LM Error (Burridge)	58.2256	(0.0000)
LM Error (Robust)	58.2400	(0.0000)
H_o: Spatial lagged dependent variable has no spatial autocorrelation.		
H_a: Spatial lagged dependent variable has spatial autocorrelation.		
Tests Stats Prob.		
LM Lag (Anselin)	0.0017	(0.9670)
LM Lag (Robust)	0.0160	(0.8992)
H_o: No general spatial autocorrelation		
H_a: General spatial autocorrelation		
Test Stats Prob.		
LM SAC (LMErr+LMLag_R)	58.2417	(0.0000)

Note: The table contains results obtained entirely from the Stata17 statistical package programme.

Spatial lag and spatial error models can be used to determine the spatial dependence (Gülel, 2013). According to test results (here Table 7) when considered separetely spatial error is significant bu spatial lag is insignificant; together, spatial lag and / or spatial error are significant. In this case, SEM-RE or SDEM-RE can be the final model. The significance of coefficients of spatial lagged independent variables should be checked (Yerdelen Tatoğlu, 2023: 346). If the coefficients of lagged independent variables are significant, the SDEM model is preferred. The hypotheses and results of these tests are as follows:

H_0: The coefficients of lagged independent variables are not significant.

H_a: The coefficients of lagged independent variables are significant.

- chi2 (5) = 99.90 prob>chi2=0.000

According to the above results, coefficients of spatial lagged independent variables are significant. It is considered appropriate to prefer the SDEM Model with random effects (RE) as the final model. SDEM-RE Model is estimated with the MLE method. This is because Elhorst (2005) argues in his study that spatial panel data can be estimated with maximum likelihood (MLE). Table 8. shows the results of the model.

Table 8. The Results of the SDEM-RE Model

VARIABLES	COEFFICIENT	Std. Err	P> |z|
lpcgov	-0.0355	0.0060	0.000*
lpcind	0.0468	0.0081	0.000*
lpcagr	-0.0229	0.0047	0.000*
lpcex	-0.0097	0.0039	0.014*

lpcim	0.0153		0.0045	0.001*	
wlpcgov	-0.1102		0.0149	0.000*	
wlpcind	0.0522		0.0184	0.000*	
wlpcagr	-0.0299		0.0087	0.001*	
wlpcex	-0.0320		0.01150	0.005*	
wlpcim	0.0420		0.01157	0.000*	
c	8.4664		0.0610	0.000*	
Within R^2	0.50	**Log-likelihood**	775.1975		
Overall R^2	0.41	**λ**	0.1528	(0.000*)	

Note: * Significant at 0.05 level. The dependent variable is lgdppc. **lgdppc**: natural logarithmized gross domestic product per capita. **lpcgov**: per capita government electricity consumption in natural logarithmized form. **lpcind**: per capita electricity consumption in the industry in natural logarithmized form. **lpcagr**: per capita electricity consumption in agricultural irrigation in natural logarithmized form. **lpcex**: natural logarithmized exports per capita. **lpcim**: natural logarithmized import per capita. **w** in the variable name stands for spatial lag.

According to Table 8, the overall R^2 result is around 41%. The spatial error coefficient lambda (λ) is statistically significant and positive. Accordingly, there is positive spatial dependence. Hence, in the period considered in the model, neighboring provinces in Türkiye are more related to each other than distant provinces. Akarsu and Berke (2016) conduct a spatial analysis of total electricity consumption per capita in Türkiye's provinces and argue that there is no evidence of spatial dependence before 2010.

The coefficients of independent variables and their spatial lags in the SDEM-RE model are statistically significant in explaining the dependent variable lgdppc. In this context;

- A 1% increase in pcgov decreases the gdppc by 0.03%. In parallel, provinces in Türkiye are negatively affected by their neighbours' pcgov. That is, if the average govpc of the neighbours of a province increases by 1%, the gdppc of that province decreases by 0.11%.
- A 1% increase in pcind increases the gdppc by 0.04%. In parallel, provinces in Türkiye are positively affected by their neighbours' pcind. That is, 1% increase increases the gdppc of those provinces by 0.05%.
- A 1% increase in pcagr decreases the gdppc by 0.02%. In parallel, provinces in Türkiye are negatively affected by their neighbours' pcagr. That is, 1% increase decreases the gdppc of those provinces by 0.02%.

The coefficients of control variables and their spatial lags are statistically significant in explaining the dependent variable lgdppc. In this context;

- A 1% increase in pcex decreases the gdppc by approximately 0.01%. In parallel, provinces in Türkiye are negatively affected by their neighbours' pcex. That is, 1% increase decreases the gdppc of those provinces by 0.03%.
- A 1% increase in pcim decreases the gdppc by 0.01%. In parallel, provinces in Türkiye are positively affected by their neighbours' pcim. In other words, 1% increase increases the gdppc of those provinces by 0.04%.

Electricity consumption can be disaggregated into subgroups, which may show different patterns across regions. (Borozan, 2017).

4. Findings

While the maps presented in the study show regional clustering and regional differences, Moran's I statistics reveal spatial interactions. According to Local Moran's I statistics, positive correlation is predominant in variables (except gov). Accordingly, it can be argued that there is a clustering in gdppc in the provinces with industrialisation such as Istanbul, Kocaeli and Bursa in the provinces falling in the HH region which are statistically significant, and that regional development is particularly concentrated here. Furthermore, the study statistically shows that the provinces belonging to the LL region for the gdppc variable (such as Ağrı, Batman, Diyarbakır) are mostly located in the relatively underdeveloped eastern region of

Türkiye. Local Moran's I statistics of ind and agr, which are sectoral electricity consumption indicators, are positively correlated. For ind; Bursa, Hatay, Istanbul, Kocaeli, Osmaniye and Tekirdağ belong to the HH region. Accordingly, it is clear that the ind is concentrated in the Marmara region and east of the Mediterranean region and it is essential for policy makers to take these regions into account. For agr: Diyarbakır, Konya, Mardin, and Şanlıurfa provinces belong to the HH region. Accordingly, the intensity of agr in these regions requires the design of policies such as making agriculture sustainable and prioritising productivity.

In addition, Global Moran's I statistics showed that gdppc and ind are positively correlated and not very volatile between 2013-2021. In this context, the fact that gdppc remains between 0.60 and 0.70 indicates that regional disparities continue in that period and that regional inequality has not changed much over time. The fact that the LISA statistic for the gdppc variable for 2021 is concentrated in the HH and LL regions is evidence of the existence of regional inequality. For ind, it means that industrial activities are concentrated in certain regions in the period 2013-2021 and this concentration does not change much over time. However, after 2013 and 2014, the agr entered a significant decline until 2021 in the case of positive correlation. In this context, the relatively high positive autocorrelation in the agr at the beginning means that agricultural activities were concentrated in certain regions in that period, while its decrease over time can be inferred that it converged to similar consumption levels in neighbouring provinces. In other words, agr has spread across the country in a balanced manner over time. Determining the reasons leading to this change is a subject for further studies. Although the global Moran's I statistics of gov are not significant, the Local Moran's I statistic for 2021 is only significant for Ankara, which falls in the negative correlation zone (HL).

According to the SDEM-RE spatial panel model, electricity used in government offices and electricity used in agricultural irrigation affect GDPPC negatively, while electricity consumption in industry affects GDPPC positively. There are few studies in the literature on sectoral electricity consumption in Türkiye. Accordingly, Turkmen & Yarbasi (2023) show that there is no causal relationship between industrial electricity consumption and growth in only 15 of the NUT2 (26 regions).

In government offices across Türkiye, the use of electric heaters, coolers, tea rooms using electric heaters, etc. in violation of the regulation leads to a large consumption of electrical energy (Yılmaz and Sungur, 2020: 227). Therefore, inefficient use of resources in the public sector may lead to deterioration in the general economic situation of the country. This conclusion is in line with the findings of the case study.

The use of old technologies in the agricultural sector requires a large amount of electricity, and the efficiency of old machines remains poor compared to agricultural vehicles operating with modern technology (Shameem et. al. 2022: 1730). Therefore, although the electricity consumption in agricultural irrigation in Türkiye is high, it does not contribute strongly to GDPPC, which points to the issue of energy wastage. Economic activities for energy efficiency in agriculture can be supported by shifting from old technologies to innovative and modern agricultural practices across the country.

5. Discussion

In this study, the relationship between sectoral & regional electricity consumption and regional development is investigated by spatial analysis and the findings are presented. Covering 81 provinces, this study evaluates electricity consumption in detail. In this discussion section, the implications of the findings for this study are discussed and compared with the findings of other studies.

There are reasons for the positive effect of ind on gdppc. For example, "Kaldor's law" which explains the positive relationship between the industrial sector and growth. The industrial sector is one of the driving forces of economic growth in Türkiye (Arısoy, 2013) and both economic growth and the sustainability of economic development depend on production, and production depends on energy inputs (Batu Ağırkaya, 2022: 2330). In this respect, the positive effect of ind in the study and the ind of neighboring provinces on gdppc can be explained by inter-provincial trade and industrial cooperation that contributes to economic development. In addition, this finding is positive for the development policies of regions in Türkiye and policies to increase industrialization should be supported.

Although the negative impact of agr on gdppc in Türkiye does not seem to be in line with the general expectation, some reasons can be explained. For example, Tufaner (2021) argues that the value added of the agricultural sector does not contribute sufficiently to economic growth. Önder (2020) argues that lost and illegal electricity use is caused by agricultural irrigation and infrastructure problems and poses a serious problem for the national economy. In their study, Vatandaş and Özgüven (2024) argue that some negativities due to climate change lead to a decrease in yield and quality in agricultural production.

Inefficient electricity consumption and inefficiency in sectoral electricity consumption may not provide a sufficient increase in gdppc. In addition, problems of lost and illegal electricity use can also be seen among these reasons. Therefore, electricity should be used more efficiently in the agricultural sector. Rural development policies may also need to be re-evaluated.

The effect of gov on gdppc is negative. The reason for this finding may be related to the efficiency of energy use in the public sector. Özgür & Aydın (2020) argue in their study that if individual and organizational performance in the public sector is done well and if public sector employees in Türkiye work effectively and efficiently, waste of resources can be prevented. Duman & Duman (2016) reveal significant differences in the public and private sectors. Karahan (2014) concluded in his study that although it is known that competitiveness is in the private sector, competitiveness advantage can also be achieved in the public sector.

It can be said that energy consumption in public buildings is not in a competitive production process compared to the private sector. Therefore, gov may have a limited impact on gdppc. Related to this inference, optimizing energy consumption in government offices would be an important step in terms of sustainable regional development policies.

The relationship between electricity consumption and development/regional development has been the subject of research. The empirical part of this paper is based on the empirical part of this study, which aims to understand the impact of sectoral and regional electricity consumption on regional development. In this context, there are results from different periods and methods in the literature, which provide important references for this study. The finding of Ağır & Kar (2010) that the per capita electricity consumption of 81 provinces positively affects the level of development is partially similar to the findings of this study. In addition, this research is also similar to Fei et al. (2011) since spatial effects are taken into account and spatial interaction is observed. In addition, Pata & Terzi (2017) and Çınar et al. (2019) found a causality relationship between electricity consumption and economic development, while Vurur (2022) revealed a long-run relationship. Kazanasmaz, Demirel, Karatepe & Hızarcı (2023) showed both a long-run relationship and a unidirectional causality relationship. These studies provide a reference for the statistically significant relationship between electricity consumption and gdppc in this study. However, many studies in the literature have shown that electricity consumption indicators positively affect economic growth and development.

Conclusion

In this study, Moran's I statistics and spatial panel econometrics are utilised for 81 provinces of Türkiye covering the years 2013-2021. According to the findings, it is seen that there are spatial clusters in which 81 units in Türkiye, which have border neighbourhoods with each other, affect each other spatially. This finding confirms Tobler's (1970) proposition that '...things that are close to each other are more related than things that are far from each other'.

In this study, the Spatial Durbin Error Model (SDEM) was finally deemed appropriate by searching for the most appropriate model by conducting the necessary pre-tests. This model was estimated with random effects and using maximum likelihood estimator. In the model; lgdppc is the dependent variable, lpcgov, lpcind and lpcagr are the main independent variables, and lpcex and lpcim are the control variables. pcgov and pcagr affect the gdppc negatively, while pcind affects it positively. pcex affects the dependent variable negatively, while pcim affects it positively. These results are the same to the direction of the spatially lagged independent variables

According to the findings, there are problems of productivity and value added in the agricultural sector. Therefore, modern techniques in agriculture can be followed and made widespread. Economic activities that will enable energy efficiency can be carried out. Since electricity consumption in public offices negatively affects GDPPC, awareness raising activities can be carried out for the bureaucracy, public institutions and organizations to use electricity consumption efficiently. This result may have been obtained because public institutions do not have a direct contribution to production and growth.

Since electricity consumption in the industrial sector in Türkiye has a positive impact on GDPPC, industrial investments can be encouraged. In addition, the negative effect of exports on gdppc may indicate that exports of low value-added products are intensive. Since imports contribute positively to gdppc, efficient use of imported inputs can be recommended for the development of domestic production capacity. Therefore, since economic relations between provinces can be revealed in this study, policy makers can benefit from these relations in regional development strategies. The finding that electricity consumption in different sectors affects gdppc differently supports the neccessity of using sectoral rather than aggregate electricity consumption as a determinant of gdppc.

As a result, observing and comparing the maps of variables, finding a parallelism between variables can be sources of information to make correlation predictions. Global and Local Moran's I statistics allow important inferences to be made for regional development. Spatial panel econometric methods provide information about the spatial interaction of neighbouring regions and the severity and direction of the effect. Therefore, in this study, many findings have been revealed by using various methods and utilising the economics-geography relationship. In the light of these findings, regional differences in the economic development level of regions in Türkiye point to the importance of regional development policies. For balanced growth and sustainable regional development, strategies that prioritise electricity consumption should be determined.

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