Socio-economic and development disparities over the long-run: exploring spatial heterogeneities in the case of Turkey

Hasan Engin Duran
(corresponding author)
PhD, Izmir Institute of Technology,
Faculty of Architecture,
City and Regional Planning
Department,
Turkey
Email: enginduran@iyte.edu.tr

Burcu Değerli Çifçi[1]
Email: burcudegerli@iyte.edu.tr

Berfin Karabakan[1]
Email: berfinkarabakan@iyte.edu.tr

Fehmi Doğan
PhD, Izmir Institute of Technology,
Faculty of Architecture,
Department of Architecture,
Turkey,
Abu Dhabi University,
College of Engineering,
Department of Architecture,
United Arab Emirates
Email: fehmidoğan@iyte.edu.tr

Keywords
socioeconomic and
development disparities,
spatial heterogeneity,
GWR,
nonparametric regressions

The aim of this paper is to explore the evolution of socioeconomic development and income disparities and convergence patterns across Turkish provinces, emphasizing the impact of spatial heterogeneities. We propose two types of contributions to the literature. First, most of the studies that apply the β-convergence method presume a unique β parameter, assuming that all regions homogenously converge to the steady state at the same pace. However, we argue that relaxing this assumption by way of considering spatial heterogeneities might be more informative. Second, we provide a simple solution to a severe problem: The neoclassical model assumes a monotonic saddle path along which economic fluctuations are not considered, which might be particularly influential with regard to convergence when the time span is too short to capture long-term evolution. Many empirical studies cover only short periods, which may be easily dominated by recessions or expansions, significantly biasing the results. To overcome this problem, we look into two datasets covering long periods (1963–2017 and 1975–2021). Having applied various empirical methods, such as spatial regressions, GWR and nonparametric regressions, we obtain several results. First, at the country level, there is empirical evidence of regional convergence and decreasing development inequalities. Second, however, this convergence process is not valid in all areas. We conclude that there is nonnegligible spatial heterogeneity that should be taken into account in such analyses.

[1] For affiliation see Hasan Engin Duran, PhD.

Introduction

In the literature on economic disparities, many papers have analysed the tendency towards income inequalities across countries/regions over the long run (see Magrini 2004, Cörvers–Mayhew 2021 for a review). These analyses rely mostly on the neoclassical (NC) growth model and on an implicit convergence hypothesis. The NC model states that under certain assumptions, economic growth relies on capital accumulation, labour, savings and technological progress (Ramsey 1928, Swan 1956, Cass 1965, Koopmans 1965, Barro–Sala-i Martin 1991, 1992, 1995, Solow 1956). Moreover, assuming all else is equal, it is hypothesized that economies with comparatively lower per-head initial incomes progress faster than other economies due to decreasing returns on production factors; thus, all economies will tend to approach a steady state at which income disparities will disappear and there will be a homogenization of prosperity (Solow 1956, Swan 1956, Baumol 1986, Barro–Sala-i Martin 1991, 1992, 1995, Armstrong 1995, Armstrong−Taylor 2000).

In the literature, an alternative view is proposed by proponents of economic geography underlying the necessity of including spatial properties in economic analysis (Krugman 1991, 1997, [9], Krugman−Venables 1992). Similarly, cumulative causation theory (Myrdal 1957) emphasizes the spatially cumulative process of growth and the enlargement of spatial disparities.

By following the premises of economic geography and the neoclassical view, the literature has examined whether economic disparities and inequalities are entrenched in spatial disparities, as highlighted by Kanbur and Venables (2005), and it has been questioned in the literature whether they consequently contribute to social inequality (Israel−Frenkel 2018).

In a regional context, several empirical studies have analysed the evolution of disparities and convergence over the last several decades (Barro–Sala-i Martin 1991, 1992; Purwono et al. 2021, Egri−Tánczos 2018, Maulana−Aginta 2022, Nemes Nagy−Tagai 2011). Studies on the US primarily point to the convergence of regional/state-level incomes to each other over the last century (Rey−Montouri 1999, Carlino−Mills 1993). Although far from conclusive, studies on EU regions indicate a convergence process (Cuadrado-Roura 2001, Goecke–Hutner 2016, Armstrong 1995). The decrease in regional inequalities has been argued to be driven mostly by rising factor mobility, increased structural (cohesion) funds targeted at low-income regions, advancements in ICT and innovation, knowledge spillovers, and the creation of human capital, whereas increasing (or persistent) inequalities are mostly due to inadequacy in investments, productivity, and human capital in backwards regions (Solow 1956, Barro–Sala-i Martin 1991, 1992, Armstrong−Taylor 2000, Baumol 1986, Lucas 1988, Romer 1986, 1990, Mankiw et al. 1992, Grossman−Helpman 1990).

It has been emphasized in the literature that examining the role of spatial dependence and spillovers with regard to economic disparities is important. Regardless of the discussions about the speed of economic convergence, it is hypothesized that in certain circumstances, there could be nonconvergence (or slow convergence) in certain places/areas (Beenstock–Felsenstein 2008, Ramajo et al. 2008). We test this in the case of Turkey by considering spatial heterogeneity as a factor in our calculations and examining a longer time span, which might mitigate some of the problems related to selecting a homogenous period.

There are a number of studies that have historically dealt with this issue in the case of Turkey; however, the findings of these studies have been inconclusive as to whether there is convergence. Among the most notable ones, [6] found conditional convergence among geographical regions during the 1975–1990 period. In contrast, Temel et al. (1999) examined the same period and determined that there are expanding economic disparities across the provinces. According to Erk, Ateş, and Direkçi (2000), who focused on the 1979–1997 period, there was no convergence across geographical regions and provinces. Sağbaş (2002) highlighted the reduction in inequalities across provinces between 1986 and 1997. Enlarging income disparities were found across provinces over the 1975–2000 period ([8]). Gezici–Hewings (2007), focusing on the 1980–1997 period, found declining inequalities, whereas Yıldırım et al. (2009) found narrowing inequalities from 1987 to 2001. Kırdar and Saraçoğlu (2012) state that income inequality across provinces expanded during the 1975–2000 period. Karahasan (2015) examined the NUTS-2 region and observed that income disparities increased between 2003 and 2008. Karaca (2018), covering the longest time span (1960–2010) among all related studies, emphasizes rising inequalities. Although these studies are inconclusive, the commonality is the presence of a remarkable level of regional inequality.

In contrast to studies of income inequality, regional disparities in human/socioeconomic development have attracted limited attention, as they represent welfare (or synonymously the well-being) from a wider perspective. While GDP per capita measures only income level, "development" indicates not only the level of income but also the level of many other aspects, such as social, environmental, education, health and other related issues (Ünal 2008, Yoloğlu 2021). Originally, the neoclassical growth theory and convergence hypothesis were proposed, particularly for income levels (Solow 1956, Barro–Sala-i Martin 1991). However, we wish to adopt a wider perspective on development and welfare. Hence, we will mainly analyse inequalities in human/socioeconomic development, but we will also provide an additional analysis of income disparities.

Fewer studies have investigated regional disparities in human/socioeconomic development. Ünal (2008) studied human development disparities across Turkish provinces by taking into account income, health, and education variables. Similarly, Gülel et al. (2017, 2021) compared human development levels across provinces/regions. These limited studies revealed large disparities across regions. The socioeconomic development disparities were specifically analysed by Yoloğlu (2021) across the Turkish districts over the period 1980–2004. Yoloğlu (2021) found that up to a certain threshold of development, there is convergence among the districts, whereas after the threshold, there is divergence. There are also other studies in the literature that have focused on similar issues (for further information, see Şen et al. 2006, Özkubat–Selim 2019). In short, the results on regional inequalities in Turkey are far from conclusive with regard to whether there is convergence or divergence across provinces since the results change substantially with respect to the period analysed and the adopted methods.

We seek to extend the literature in two dimensions:

First, in the literature on regional disparities, a common method of estimating the evolution of inequalities is the β-convergence method, according to which the initial income of regions is regressed on growth rates over a given time period. While doing this, a great majority of the studies assume a unique "β" convergence parameter in a linear framework, assuming that all regions homogenously approach the unique steady state at the same pace (Barro–Sala-i Martin 1991, 1992, Armstrong 1995, Duran 2015, Eckey−Turck 2007). However, it is valuable to relax this assumption and allow for spatial heterogeneity and nonlinearity in the convergence process since regions differ substantially from each other in terms of industrial, social, economic, and demographic structure (Duran 2015, Yoloğlu 2021, Beenstock−Felsenstein 2008, Ramajo et al. 2008). Doing so has merits in that it might be more informative about the evolution of development disparities and convergence. One possible way of taking into consideration such heterogeneity is the geographically weighted regression (GWR) method, which is employed by a limited number of studies in this context (see Öcal–Yildirim 2010, Karahasan 2018, Yildirim–Öcal 2013 for some exceptions in the case of Turkey). However, the majority of the studies using GWR adopted per capita GDP in convergence analysis, but we also focused on socioeconomic development, which represents a more general and conventional measure of welfare and well-being.

Second, we provide a simple solution to a severe problem faced in the current literature. The NC model assumes a monotonic saddle path along which economic fluctuations are not taken into account; however, fluctuations might influence convergence dynamics, particularly when the time span is too short to capture long-term evolution (Duran 2014, Magrini et al. 2015, Petrakos et al. 2005). Many empirical studies on Turkey adopt a 15–20-year period of study, which may overlap primarily with a recession or prolonged expansion that may significantly bias the results, as regional inequalities may evolve in a procyclical or countercyclical fashion (Duran 2014, Magrini et al. 2015, Petrakos et al. 2005, Pekkala 2000). Hence, the period of analysis should be as long as possible to mitigate such distortions driven by business cycle effects. Consequently, we analysed two periods, 1963–2017 and 1975–2021, which represent quite long time spans (54 years and 46 years, respectively) in the literature on Turkey in this field.

Thus, the purpose of this study is to analyse the extent of socioeconomic and development disparities and their evolution and convergence patterns across Turkish provinces by exploring spatial heterogeneities over a long period of time.

Data and method

Theoretical and methodological framework

The neoclassical model considers the following production framework (Ramsey 1928, Swan 1956, Cass 1965, Koopmans 1965, Barro–Sala-i Martin 1991, 1992, 1995, Solow 1956):

$$y_t = Ak_t^{\alpha} \quad (1)$$

where y is the income per capita and k is the per capita capital accumulation. A is the level of knowledge, which may also be termed total factor productivity; thus, the economic growth process is linked to capital accumulation and progress in technology.

After linear approximations and simplifications, scholars have developed a reduced form of convergence regression model (Baumol, 1986; Barro–Sala-i Martin 1991, 1992; Rey–Montouri 1999; Gömleksiz et al. 2007):

$$ln\left(\frac{y_{i,t}}{y_{i,t-k}}\right) = \alpha + \beta ln\, y_{i,t-k} + \delta Z_{i,t-k} + u_{i,t} \quad (2)$$

$ln\left(\frac{y_{i,t}}{y_{i,t-k}}\right)$ represents economic growth over the period of analysis, whereas $ln\, y_{i,t-k}$ denotes the initial income; *Z* represents the set of conditioning (control) variables, which may consist of capital stock, investments, labour force-related variables (population growth, human capital), innovation, technology, savings, etc. (Barro–Sala-i Martin 1991, 1992, 1995, Baumol 1986, Beenstock−Felsenstein 2008; Lucas 1988, Romer 1986, 1987, 1990, Mankiw et al. 1992, Grossman–Helpman 1990, Yanıkkaya 2001; Gömleksiz et al. 2007).

The literature has focused on two convergence classes. **i.** In the absolute convergence equation, δ is assumed to be equal to zero, and a significant β<0 implies a convergence pattern and declining inequalities across regions; in contrast, the **conditional** convergence framework occurs when $\delta \neq 0$, which assumes that the features of the steady state rely on the control variables (Z) (Barro–Sala-i Martin 1991, 1992, 1995; Baumol 1986; Lucas 1988; Beenstock-Felsenstein 2008; Romer 1986, 1987,1990; Mankiw et al. 1992; Grossman–Helpman 1990; Yanıkkaya 2001; Gömleksiz et al. 2007).

We opt for the former (absolute convergence) since the data on provincial control variables (such as physical capital stock, labour, and human capital) historically are unavailable and beyond the purpose of our study.

Data and variables

We obtained social and economic development data by using the official data sources listed in Table 1 below [12], [13].

Below, in Table 1, we document the variables used and their definitions, sources and measurements.

Table 1

Definition of variables

Variable name	Definition and measurement	Data sources
dev1963	relative socio-economic development (SED) score of 67 provinces in 1963; the index is calculated in the following way: *dev1963*=$(SED_i - min)/(max - min)$ [15]	https://www.sanayi.gov.tr/merkez-birimi/b94224510b7b/sege/il-sege-raporlari (report for 1969) report name (in Turkish): Türkiye'de İller İtibariyle Sosyo Ekonomik Gelişmişlik Endeksi, State Planning Organization, Prime Ministry, 1969 [13]
dev2017	relative socio-economic development (SED) score of 67 provinces in 2017; the index is calculated in the following way: *dev2017* = $(SED_i - min)/(max - min)$ [15]	https://www.sanayi.gov.tr/merkez-birimi/b94224510b7b/sege/il-sege-raporlari (report for 2017) report name (in Turkish): İLLERİN ve BÖLGELERİN SOSYO- EKONOMİK GELİŞMİŞLİK SIRALAMASI ARAŞTIRMASI SEGE-2017, Ministry of Industry and Technology, General Directorate of Development Agencies, Republic of Turkiye [12]
d_dev=dev2017–dev1963	change in relative SED over the 54 years, representing the relative development progress of the provinces	own calculation
ln(rgdpc1975)	relative real per capita GDP for 67 provinces at 1987 constant prices *ln(rgdpc1975)* = *ln*$(gdpc_i/\overline{gdpc})$ *where* $gdpc_i$ *is the GDP per person,* $\overline{gdpc}$ *is the cross-provincial mean*	[8], [17], Kasman–Turgutlu (2009)
ln(rgdpc2021)	relative real per capita GDP for 67 provinces, deflated by using TUIK's CPI index *ln(rgdpc2021)* = *ln*$(gdpc_i/\overline{gdpc})$	[17]
d_rgdpc= ln(rgdpc2021)– ln(rgdpc1975)	progress in relative per capita GDP	own calculation

The first class of variables is development scores (dev). I*t* is in the form of relative values, calculated by using *dev*= $(SED_i - min)/(max - min)$, where SED_i is the socioeconomic development score of province i.

The development variable SED includes many different subvariables (headings) related to the social, economic, environmental, and related development of variables. In detail, development variables in 1963 include a mixture of the following variables related to urbanization, modernization of agriculture, industrialization, organization, and services [12], [13]. Similarly, the development variable in 2017 also included many different subvariable groups, including demographic variables, innovative capacity, education, accessibility, health, employment, financial variables, quality of life and competitiveness (Tekin−Doğan 2022) [12], [13]. These indicators are similar to the UNDP's human development indices but include a broader range of indicators [15].

Max. and min. operators represent the highest and lowest values (across provinces) of development scores in a specific year. Hence, the dev variable takes values between 0 (least developed) and 1 (most developed province). *dev1963* and *dev2017* represent the relative scores of development for the initial year and end year, respectively. *d_dev = dev2017–dev1963* denotes the change (progress) in the development scores.

The second class of variables is per capita GDP. The initial year is 1975, and the end year is 2021. The variables are in relative form, and the change in the relative per capita GDP represents the comparative progress in economic growth. Such that ln(rgdpc1975) denotes the initial relative GDP per capita (with constant 1987 prices); each value is divided into a cross-provincial mean, and the relative GDP is obtained as *ln(rgdpc1975) =ln* $(gdpc_i/\overline{gdpc})$. For the end-year, ln(gdpc2021) similarly represents the relative per capita income in 2021 (deflated by TUIK's CPI index) [17]. Finally, *d_rgdpc* is the change in relative per capita income over time.

The development variables capture the development of provinces not only in relation to income, health and education but also in relation to social factors and many other dimensions (the details can be found in the related reports cited in Table 1).

Another important note is related to the number of provinces analysed. In Turkey, there were 67 provinces in 1963 and 1975 and 81 provinces in 2017 and 2021, as some of the districts became provinces over time, particularly after 1980. For 1963, we use all 67 available provinces. For the year 2017, we assume that the other 14 provinces are blank (missing value in the analysis, in grey in Figure 4) and focus on the other 67 provinces. The 67 provinces in 1963 were identical to those in 2017, keeping in mind that 14 recently emerged provinces had belonged "as districts" to other provinces in 1963.

Descriptive and ESDA analysis

In terms of descriptive analysis, we focus on the development indicator since it is our focus variable. We initially provided descriptive statistics (Table 3). The analysis included basic measures (mean, median, standard deviation, maximum, minimum) of the two variables (dev1963, dev2017) as well as distributional properties such as skewness, kurtosis and Jarque–Bera test statistics of normality (Jarque–Bera 1980, 1987, Bera–Jarque 1981).

Next, we present the kernel density estimations in Figure 1 of the two variables (dev1963 and dev2017) to visualize the explicit view and evolution of the distributions

(Simonoff 1996, Marron–Nolan 1988, Hardle 1991, 1992, [16]). Accordingly, in Figure 2, basic plots (maps) of dev1963 and dev2017–dev1963 are presented.

To investigate the possible spatial associations, we applied Global Moran I plots (Figure 3) to the dev1963 and dev2017–dev1963 variables. The table shows the degree to which the provinces are correlated with their neighbouring provinces for a specific variable (see Moran 1950, Rey–Montouri 1999 for details). For instance, positive and significant statistics indicate a positive spatial dependence of high (low)-valued provinces surrounded by high (low)-valued neighbours. A threshold type inverse distance (distance band) spatial weight matrix has been employed ([7], Anselin 1988, [1]).

Regression analysis

The general regression framework we consider is as follows:

$$dev_{i,t} - dev_{i,t-k} = \alpha + \beta dev_{i,t-k} + e_{i,t} \quad (3)$$

$$ln(rgdpc_{i,t}) - ln(rgdpc_{i,t-k}) = \alpha + \beta ln(rgdpc_{i,t-k}) + e_{i,t} \quad (4)$$

To choose the correct model, we apply Lagrange multiplier tests (LMs) to the regression in Equation 3. There are five types of spatial autocorrelation tests: *LM-error, LM-lag, robust LM-error, robust LM-lag,* spatial autoregressive moving average (SARMA) and Anselin–Kelejian tests. *LM-error* and *robust LM-error* tests assume spatial dependence among residuals, whereas *LM-lag* and *robust LM-lag* tests assume spatial dependence in the dependent variable. SARMA provides a comprehensive test (Anselin 1988, Elhorst 2010, 2014, [3], [4], [5], Anselin et al. 1996, Anselin–Rey 1991, Anselin−Moreno 2003). A threshold type inverse distance (distance band) spatial weight matrix has been employed ([7], Anselin 1988, [1]).

The test results are provided in Table 2.

Table 2

Spatial LM tests*

Test type	Test statistic	P value
LM lag	18,122***	0,0000
Robust LM lag	4,515***	0,0336
LM error	20,33***	0,0000
Robust LM lag	6,724***	0,0095
SARMA	24,846***	0,0000
Anselin–Kelejian test	6,604***	0,0102

* *Data sources:* [10]–[17].

** Represents statistical significance at 5 % (0.01<p-value<0.05), *** represents statistical significance at 1 % (p-value<0.01).

Note: To run the Anselin-Kelejian test, the 2SLS model is run first using the GMM estimator in the GEODAspace program, in which *d_dev* is the endogenous variable and ln(rgdpc1975) is the instrument (Kelejian−Prucha 1998, 1999, 2007, Anselin−Kelejian 1997, [2], Arraiz et al. 2010, Drukker et al. 2013).

Regardless of the type of test, they are all significant, indicating the necessity of incorporating, particularly, spatial error models since they are more significant.

As two of the most comprehensive models, we prefer the SEM and Durbin–SEM. A general model is provided by Durbin (1960):

$$d\_dev_{i,t} = \alpha + \beta\ dev_{i,t-k} + \emptyset W ln\ dev_{i,t-k}\ \ +e_{i,t} \quad e_{i,t}=\lambda \mathrm{W}\ e_{j,t} \tag{5}$$

Differently from Equation (3), spatial components are added. W represents the spatial weight matrix. We employ two types of models: i. the full model, as in Equation 5 (Durbin–SEM); and ii. SEM model when $\emptyset = 0$, which are estimated by using a maximum likelihood estimator (Fisher 1922a, b, Manski 1993, Anselin 1988, Elhorst 2010, 2014, Anselin et al. 1996, LeSage 2008, LeSage–Pace 2009, Anselin–Rey 1991, Durbin 1960).

In terms of the spatial weight matrix, we adopted primarily a threshold-type inverse distance (distance band) spatial weight matrix since it is more convenient and reliable since it provides a continuous measure of proximity rather than assuming discrete (1/0) neighbourship, as in other matrix forms.

Focusing on 67 provinces and excluding 14 provinces did not harm the spatial weight matrices since there were no provinces left without a neighbour. Hence, technically, this approach did not cause an error. However, we also obtained alternative results using a queen-type contiguity matrix ([7], Anselin 1988, [1]).

Alternatively, we adopt the following model using GDP per capita:

$$d\_rgdp_{i,t} = \alpha + \beta ln(rgdpc_{i,t-k}) + \emptyset W ln(rgdpc_{i,t-k}) + e_{i,t} \quad e_{i,t}=\lambda W\ e_{j,t} \tag{6}$$

Next, we incorporated spatial heterogeneities by referring to geographically weighted regression (GWR) (Paez et al. 2011, Fotheringham et al. 2002). This is a useful tool for estimating the local coefficients of a certain independent variable. In our context, the β coefficient, assumed previously to be spatially invariant, can be estimated for specific regions (Paez et al. 2011, Fotheringham et al. 2002). As a result, the GWR regression has the following form:

$$dev_{i,t} - dev_{i,t-k} = d\_dev_{i,t} = \alpha + \beta_i dev_{i,t-k} + u_{i,t} \tag{7}$$

$$d\_rgdp_{i,t} = \alpha + \beta_i \ln(rgdp_{i,t-k}) + u_{i,t} \tag{8}$$

While the dependent and independent variables are the same as in Equations 3 and 4, β_i is allowed to vary across provinces, thereby capturing spatial heterogeneity.[2]

Finally, we apply a nonparametric regression to capture the nonlinearity in the convergence regression Equations 3,4. Usually, it is standard for a linear framework to assume a unique convergence parameter (β), which is spatially invariant throughout the country. By relaxing this assumption, we aim to complement the GWR analysis and allow nonlinearity with varying β across the regions. The regression function has the following shape:

$$d\_dev_{i,t} = \alpha + f(\ dev_{i,t-k}) + u_{i,t} \tag{9}$$

$$d\_rgdp_{i,t} = \alpha + f(\ln(rgdp_{i,t-k})) + u_{i,t} \tag{10}$$

The function was estimated by using two techniques: i. nearest neighbour LOESS fit, ii. Kernel Regression (Duran 2015, Nadaraya 1964, Cleveland 1979, 1981, 1993, 1994, Cleveland–Devlin 1988, Fan–Gijbels 1996, Chambers et al. 1983, Fan–Marron

[2] The data of coordinates has been obtained from [10].

1994, Watson 1964, Simonoff, 1996, Hardle 1991, 1992, [16]). Both methods are known to be superior and reliable in the literature.[3]

Empirical results

Descriptive and ESDA results

Initially, we summarize the basic distributional properties of the development scores (dev) for the initial and final years in Table 3. It is remarkable that the coefficient of variation (CoV) has declined from 0.87 (1963) to 0.56 (2017), which indicates a tendency towards a decrease in development inequalities and homogeneity of the development distribution. Nevertheless, the most recent value of the CoV (0.56) still indicates a wide gap between the provinces. The degree of skewness and kurtosis has also decreased substantially over the years. The Jarque–Bera test statistic has also fallen remarkably, which signals that the deviation of the distribution from normality has decreased (Jarque–Bera 1980, 1987, Bera–Jarque 1981). In light of these findings, one may argue that development scores tend to be distributed more homogenously and that there exists a tendency towards a normal distribution.

To complement these results, we illustrate the kernel density probability distribution of the development scores for the two different years in Figure 1. Although there was a unimodal but skewed distribution in 1963, in 2017, the visual shape of the distribution looked more similar to a normal distribution. However, it is important to note that in 2017, the distribution became bimodal since a second mode was observed.

Table 3

Descriptive statistics of development indices*

Indicator	dev1963	dev2017
Mean	0,189	0,316
Median	0,153	0,305
Maximum	1,000	1,000
Minimum	0,000	0,000
Standard deviation	0,163	0,178
CoV=standard deviation/mean	0,866	0,563
Skewness	2,480	0,885
Kurtosis	11,613	5,323
Jarque–Bera	275,782***	23,816***

* *Data sources:* [10]–[17].

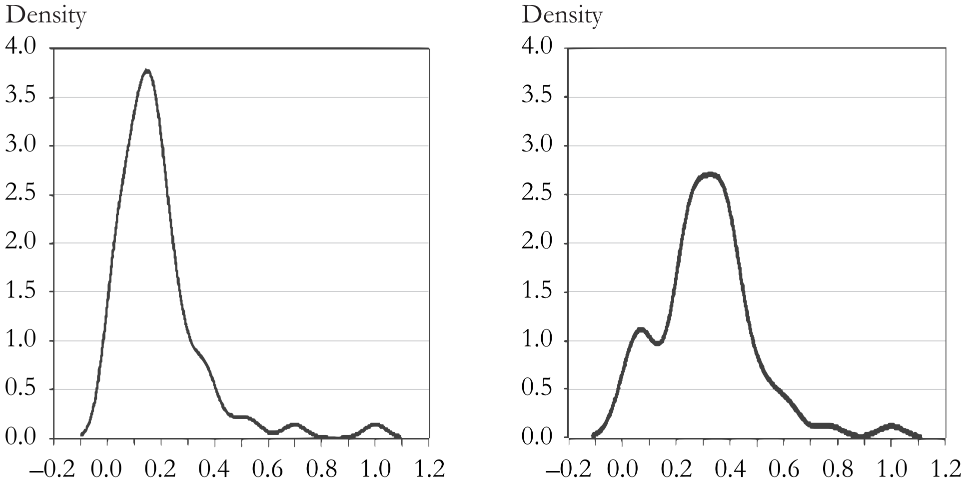
** Represents statistical significance at 5 % (0.01<p-value<0.05), *** represents statistical significance at 1 % (p-value<0.01).

[3] In terms of statistical softwares and tools, we use Eviews 4, Eviews 10, Geoda, GeodaSPace, R "SPDEP", "Spatialreg" and "SPGWR" packages and other supplementary R packages in the empirical analysis [2], [3], [4], [5]. We use the online tool at www.datawrapper.de for the creation of maps [14].

Figure 1

Kernel density plots of development indexes, normal distribution assumed*

1a. 1963 **1b. 2017**



* *Data sources:* [10]–[17].

The geographical distribution of socioeconomic development and spatial characteristics are of particular interest.

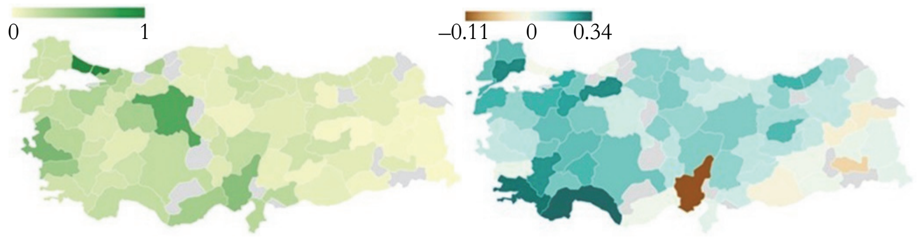
Initially, we present the maps of the initial development score (dev1963) and its change over time (dev2017–dev1963). Figure 2a clearly shows that Metropolitan, Western and Mediterranean cities, including the provinces of Izmir, Ankara, Istanbul and Adana, are the most developed places. These provinces are mostly specialized in the industrial and services sectors and are considered to have higher productivity.

In Figure 2b, we observe obvious patterns of provincial progress in development. Several southwestern provinces are located on the Aegean/Mediterranean coast and in its hinterland, several provinces surround the Istanbul Port hinterland, and some Eastern and Northern Anatolian cities have mostly experienced progress. Some socioeconomic factors might have influenced such progress: industrialization and the increasing importance of ports, trade and financial liberalization trends worldwide, and the development of the service sector, additionally, tourism might have played an important role in this development pattern (Gezici–Hewings 2007, Yildirim et al. 2009, Karaca 2004 [8], 2018, Yoloğlu 2021).

Figure 2

Plots of the variables*

2a. ***dev1963*** **2b.** ***dev2017-dev1963***



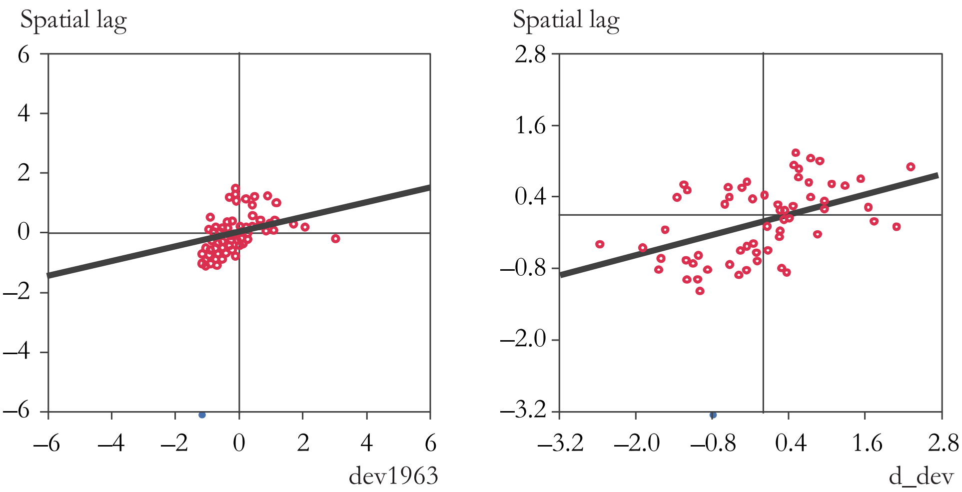
* *Data sources:* [10]–[17].

We explore the presence of spatial dependence by using Moran I plots and statistics (Moran 1950) and present the outcomes in Figure 3. For the year 1963, (3a.) The development scores' Moran's I statistic is moderate (0.24) and positive. Additionally, the progress of development over the 54 years (in Figure 3b.) exhibits a moderate and positive spatial association (0.28). Both figures demonstrate a positive sloped fit-line that represents the degree of spatial dependence.

Figure 3

Moran plots*

3a. Moran's I: 0.243 **3b. Moran's I: 0.281**



* *Data sources:* [10]–[17].

Hence, the results suggest a nonnegligible positive spatial relatedness. Spatial spillovers of development among neighbouring provinces are possibly driven by trade, financial linkages, commuting patterns, migration and the spatially cumulative (agglomerative) nature of some sectors, such as industry, manufacturing, trade, etc.

(Myrdal 1957, Armstrong 1995, Ellison−Glaeser 1999, Krugman 1991, 1997, [9], Krugman–Venables 1992, LeSage 2008, LeSage–Pace 2009, Armstrong–Taylor 2000).

Given the empirical evidence and its theoretical importance, the spatial dimension should be taken into account in the remaining analysis.

Regression analysis results

To inferentially analyse the convergence dynamics, we performed a regression analysis of three types: i. linear regression, ii. GWR, iii. Nonparametric (nonlinear) regression.

i. Linear regression

First, we estimate the regression model in Equations 3–6, in different nonspatial and spatial forms and by alternatively using i. development variable and ii. GDP per capita.

The estimation results are shown in Table 4. In the upper panel, the results of the analysis are shown for the socioeconomic development variable (dev). In column 1, there are simple OLS estimations. The estimated β coefficient is negative but not significant, indicating no evidence of convergence. SEM and Durbin–SEM are shown in columns 2–3. The story changes when spatiality is incorporated. In all spatial regressions, β is negative and significant. This provides evidence supporting convergence. Therefore, relatively less developed provinces tend to progress faster to catch up with other provinces.

Table 4

Regression results, spatial weight matrix: threshold, distance band inverse distance*

Dependent variable: d_dev	OLS	SEM	SEM–Durbin
Constant	0.139615***	0.15931***	0.122695***
y1963	–0.0661443	–0.174769***	–0.158638**
Spatial lag y1963			0.180046
Lambda		0.613221***	0.558356***
Estimation method	OLS	maximum likelihood	maximum likelihood
R-Squared	0.013766		
AIC	–127.397	–143.887	–142.854
Dependent variable: d_rgdpc	OLS	SEM	SEM–Durbin
Constant	0.00199644	2,34E+00	0.00860242
ln(rgdpc1975)	–0.263599***	–0.236681***	–0.334713***
Spatial lag ln(rgdpc1975)			0.170431
Lambda		–0.233578	–0.201412
R-squared	0.202581		
AIC	–8,601	–9,588	–9,818

* *Data sources:* [8], [10]–[17].

** Represents statistical significance at 5 % (0.01<p-value<0.05), *** represents statistical significance at 1 % (p-value<0.01).

Note: for OLS and maximum likelihood details, see Gujarati and Porter (2003).

In all spatial models, the spatial parameter (lambda) is positive and significant. Thus, development has evolved spatially such that development progress in neighbouring provinces spills over to the surrounding provinces and helps their progress. This may be triggered by trade and financial linkages among neighbouring provinces, commuting patterns and the spatially cumulative (agglomerative) nature of some sectors, such as industry, manufacturing, and trade (Myrdal 1957, Armstrong 1995, Krugman 1991, 1997, [9], Krugman–Venables 1992, LeSage 2008, LeSage–Pace 2009, Armstrong–Taylor 2000). The spatial lag of the initial development scores is also positive but not significant, supporting the previous argument above.

With regard to income convergence, the estimation results using per capita GDP are shown in the bottom panel of Table 4. The beta coefficient is consistently negative and significant in all regressions, indicating clear evidence of decreasing regional income inequalities and convergence. Overall, we report evidence of declining regional inequalities and convergence in both income levels and development degrees over the long-term period.

The results of an alternative analysis implemented by using a queen-type contiguity matrix are presented in Table 5. These results are consistent with the previous regression results in Table 5. Although there are minor differences, the main implications, such as the sign and significance of the beta coefficient, are almost the same. Hence, we can argue that the results are consistent across different weight matrices.

Table 5

Regression results, spatial weight matrix: queen contiguity matrix *

Dependent variable: d_dev	OLS	SEM	SEM–Durbin
Constant	0.139615***	0.176539***	0.11723***
y1963	–0.0661443	–0.310143***	–0.242594***
Spatial lag y1963			0.2656**
Lambda		0.745667***	0.662043***
Estimation method	OLS	maximum likelihood	maximum likelihood
R-Squared	0.013766		
AIC	–127.397	–164.863	–167.7
Dependent variable: d_rgdpc	OLS	maximum likelihood	maximum likelihood
Constant	0.00199644	–0.0115019	0.0200728
ln(rgdpc1975)	–0.263599***	–0.380827***	–0.513606***
Spatial lag ln(rgdpc1975)			0.417176***
Lambda		0.344692**	0.165228
R-squared	0.202581		
AIC	–8,601	–11,544	–20,385

* *Data sources:* [8], [10]–[17].

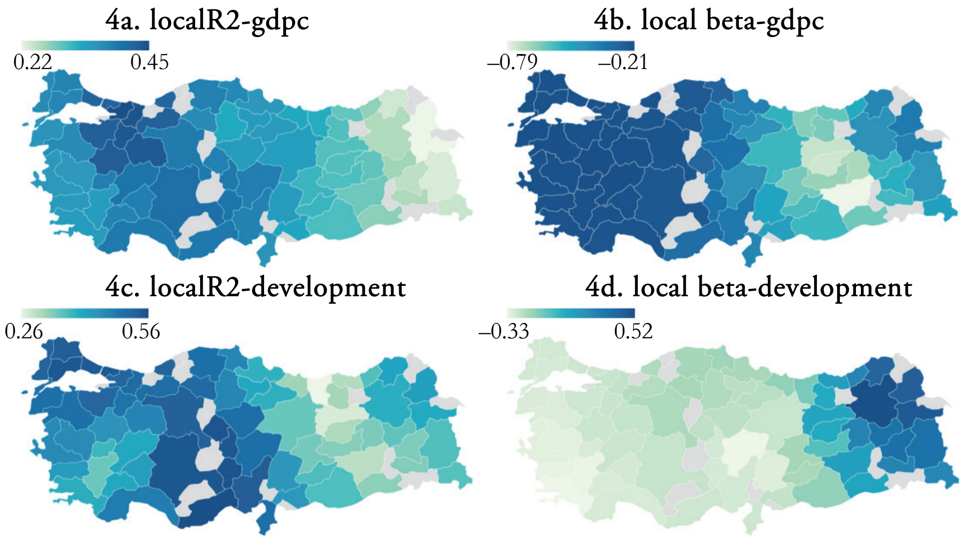
** Represents statistical significance at 5 % (0.01<p-value<0.05), *** represents statistical significance at 1 % (p-value<0.01).

ii. GWR results

As explained before, one of the main motivations of this paper is to explore the spatial heterogeneity in the convergence process (as in Karahasan 2020). The previous results in Tables 4 and 5 assume a unique convergence parameter (β), which is assumed to be spatially invariant throughout the country but which is unlikely to occur in reality. The GWR approach adopts a highly general method that allows estimation of the local convergence parameter (in Equations 7 and 8). Therefore, this method is more informative and reliable. The results are illustrated in Figure 4 (local beta coefficients and estimated R-squares).

Figure 4

GWR results*



Note: grey-coloured provinces are excluded from the study and analysis.
* *Data sources:* [8], [10]–[17].

At a glance, a rather different story appears to emerge when compared to linear regression results:

Spatial heterogeneity is also clearly present in the GWR analysis for per capita GDP (Equation 8) (Figure 4a–4b). These visual results are consistent with those of Karahasan (2020), Öcal−Yildirim (2020) and Yildirim−Öcal (2013), whose analyses adopted different regression/variable specifications and different time periods than did our study. In all the provinces, the beta coefficient is negative; however, its magnitude is quite heterogeneous, ranging between –0.79 and –0.21. The convergence speed is very slow in the western regions and faster in the majority of the middle and eastern Anatolian provinces. Hence, most of the mid-eastern and eastern provinces seem to benefit from high income convergence, which helps reduce the income gap between the eastern and western provinces, whereas several provinces in the far northeast have relatively slower convergence speeds.

Regarding the model using development scores (Equation 7, Figure 4c–4d), it is observed that the convergence parameter is negative in most of the provinces except for some provinces that have a positive convergence parameter. Hence, convergence of development in Turkey may occur in the Western, Mediterranean, Middle Anatolian, most of the Black Sea, mid-southern and some of the eastern and southeastern regions, in contrast to nonconvergence among some of the provinces in the northeast (including also some provinces along the Black Sea) and some of the remaining eastern provinces.

iii. Nonparametric regression results

To complement the results obtained by GWR, we present the results of nonparametric regression in Figure 5, which also relaxes the unique β assumption. In the upper panel, Equation 9 is applied where development scores are used, whereas in the bottom panel, Equation 10 is applied in which per capita GDP is applied.

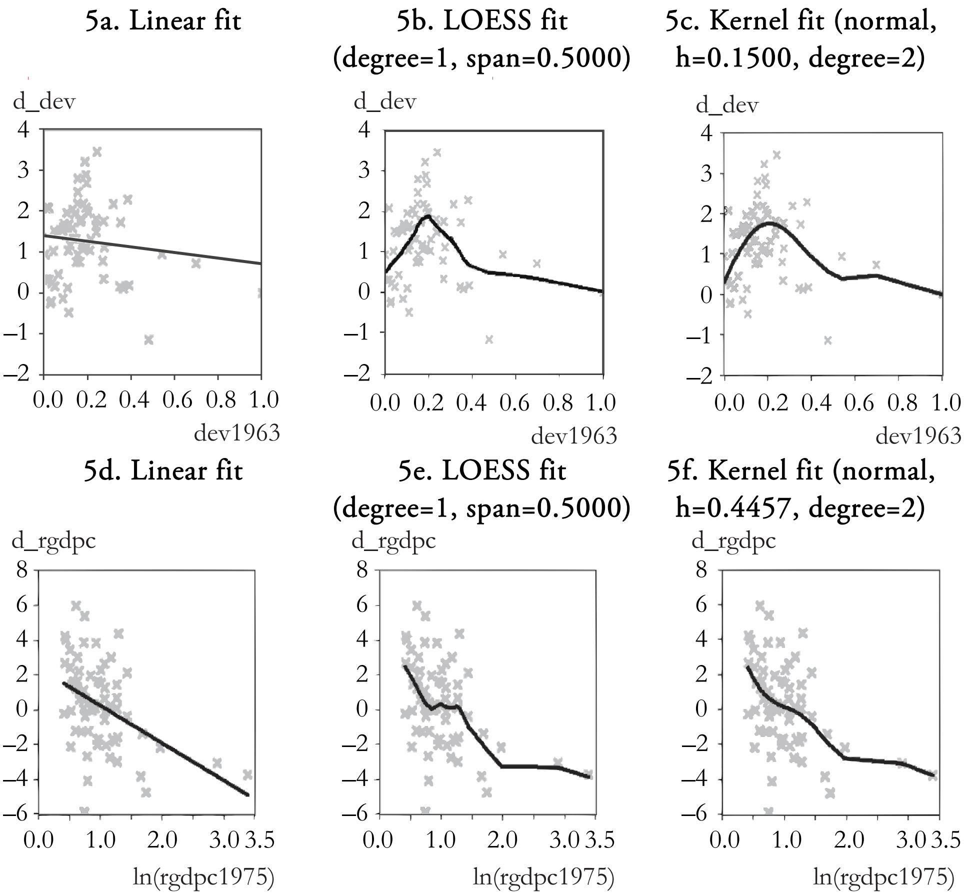
In Figure 5a, the regression estimated under the linear framework indicates a moderate convergence process. However, the nonparametric regressions in sections 5b and 5c tell a totally different story, which is quite consistent with the results obtained from the GWR analysis; therefore, less developed regions with development scores of approximately 0–0.1 progress relatively worse during development. Regions with initially moderate development scores of approximately 0.2–0.4 progressed quite well, but regions with initial development scores above 0.4 progressed relatively worse during development. These results contrast with those of Yoloğlu's (2021) study on district-level development disparities between 1985 and 2004, which also revealed a nonlinear pattern but in a different shape.

This pattern may be related to economic development over the last 54 years. In Turkey, until 1980, an import substitution growth model was applied (Akyildiz−Eroğlu 2004). Globalization, trade and financial liberalization trends worldwide increased after the 1980s and may have converted the hinterlands of metropolitan areas, tourism regions and hinterlands of major ports into growth poles/hubs, particularly in manufacturing and trade, consistent with the agglomerative nature of these sectors (Perroux 1950, 1955, Akyildiz−Eroğlu 2004, Armstrong 1995, Krugman 1991, 1997, Krugman–Venables 1992, LeSage 2008, LeSage–Pace 2009, Armstrong–Taylor 2000, Gezici−Hewings, 2007, Yildirim et al. 2009, [8], 2018, Yoloğlu 2021). Hence, middle-level developed provinces progressed more than did highly developed and least developed provinces.

With regard to the results of the analysis using income per capita, in Figure 5d shows a clear convergence of per capita income. In contrast to the results of the analysis using development scores, the nonlinear relationship in Figure 5e and 5f seems less evident, although there is some nonlinearity indicating spatial heterogeneities.

Figure 5

Nonparametric regressions, scatterplots*



* *Data sources:* [8], [10]–[17].

Conclusion

In this paper, we analysed the convergence of socioeconomic development levels across Turkish provinces between 1963 and 2017.

After applying a variety of empirical tools, we reach several important conclusions. First, at the aggregate level, there is empirical evidence that development and income levels tend to converge among provinces. In other words, the income and development disparities decrease over time.

However, at the disaggregate level, this convergence process is not homogenously valid for all regions/areas. Hence, we understand that there is spatial heterogeneity in development that should be taken into account in such analysis. Failing to do so leads to both misleading policy implications and under- or overestimation of the convergence process for particular provinces.

Our results have several important policy implications. First, there is a need for place-specific policies, particularly those targeted at the socioeconomic development of more relatively backwards regions. The further improvement of physical and social infrastructure, ICT, transportation, human and social capital, and policies targeted at mitigating outmigration and its detrimental effects are among the possible policies to be implemented. One may suggest several policies targeted at improving economic integration to the rest of the world, such that large industrial ports, logistic centres and free trade zones in less developed provinces may represent a solution.

By following comprehensive and place-specific policies can cohesion and socioeconomic development be reached for all regions; otherwise, as suggested by Israel and Frenkel (2018), allowing market forces to run production leads to economic disparity within countries. In the period between 1985 and 2005, spatial inequality increased worldwide (Kanbur−Venables 2005), and we believe that this trend has continued since then. Global trends as well as local developments highlight the necessity of policy interventions for improving economic inequality (Kanbur−Venables 2005).

REFERENCES

AKYILDIZ, H.−EROĞLU, Ö. (2004): Turkey Cumhuriyeti dönemi uygulanan iktisat politikalar *Süleyman Demirel Üniversitesi, İ.İ.B.F Dergisi* 9(1): 43−62.

ANSELIN, L. (1988): *Spatial econometrics: methods and models* Kluwer, Dordrecht. https://doi.org/10.1007/978-94-015-7799-1

ANSELIN, L.–BERA, A. K.–FLORAX, R.–YOON, M. J. (1996): Simple diagnostic tests for spatial dependence *Regional Science and Urban Economics* 26 (1): 77−104. https://doi.org/10.1016/0166-0462(95)02111-6

ANSELIN, L.−KELEJIAN, H. H. (1997): Testing for spatial error autocorrelation in the presence of endogenous regressors *International Regional Science Review* 20 (1–2): 153−182. https://doi.org/10.1177/016001769702000109

ANSELIN, L.–MORENO, R. (2003): Properties of tests for spatial error components *Regional Science and Urban Economics* 33 (5): 595−618. https://doi.org/10.1016/S0166-0462(03)00008-5

ANSELIN, L.−REY, S. (1991): Properties of tests for spatial dependence in linear regression models *Geographical Analysis* 23 (2): 112–131. https://doi.org/10.1111/j.1538-4632.1991.tb00228.x

ARMSTRONG, H. W. (1995): Convergence among regions of the European Union, 1950–1990 *Papers in Regional Science* 74 (2): 143−152. https://doi.org/10.1111/j.1435-5597.1995.tb00633.x

ARMSTRONG, M.–TAYLOR, J. (2000): *Regional economics and policy* Blackwell Publishing 3rd Edition, Wiley, USA.

ARRAIZ, I.–DRUKKER, D. M.–KELEJIAN, H. H.–PRUCHA, I. R. (2010): A spatial cliff-ord-type model with heteroscedastic innovations: small and large sample results *Journal of Regional Science* 50 (2): 592–614.

BARRO, R. J.–SALA-I-MARTIN, X. (1991): Convergence across states and regions *Brookings Papers on Economic Activity* 22 (1): 107–182. https://doi.org/10.2307/2534639

BARRO, R. J.–SALA-I-MARTIN, X. (1992): Convergence *Journal of Political Economy* 100 (2): 223–251. https://doi.org/10.1086/261816

BARRO, R. J.–SALA-I-MARTIN, X. (1995): *Economic growth theory* McGraw-Hill, Boston.

BAUMOL, W. J. (1986): Productivity growth, convergence, and welfare: what the long-run data show *The American Economic Review* 76 (5): 1072–1085.

BEENSTOCK, M.–FELSENSTEIN, D. (2008): Regional heterogeneity, conditional convergence and regional inequality *Regional Studies* 42 (4): 475–488. https://doi.org/10.1080/00343400701291500

BERA, A. K.–JARQUE, C. M. (1981): Efficient tests for normality, homoscedasticity and serial independence of regression residuals: Monte Carlo evidence *Economics Letters* 7 (4): 313–318 https://doi.org/10.1016/0165-1765(81)90035-5

CARLINO, G. A.–MILLS, L. O. (1993): Are U.S. regional incomes converging?: a time series analysis *Journal of Monetary Economics* 32 (2): 335–346. https://doi.org/10.1016/0304-3932(93)90009-5

CASS, D. (1965): Optimum growth in an aggregative model of capital accumulation *Review of Economic Studies* 32 (3): 233–240. https://doi.org/10.2307/2295827. JSTOR 2295827

CHAMBERS, J. M.–CLEVELAND, W. S.–KLEINER, B.–TUKEY, P. A. (1983): *Graphical methods for data analysis* Wadsworth & Brooks, Cole Publishing Company.

CLEVELAND, W. S. (1979): Robust locally weighted regression and smoothing scatterplots *Journal of the American Statistical Association* 74 (368): 829–836. https://doi.org/10.2307/2286407

CLEVELAND, W. S. (1981): LOWESS: A program for smoothing scatterplots by robust locally weighted regression *The American Statistician* 35 (1): 54. http://dx.doi.org/10.2307/2683591

CLEVELAND, W. S. (1993). *Visualizing data* Hobart Press.

CLEVELAND, W. S. (1994): *The elements of graphing data* Hobart Press.

CLEVELAND, W. S.–DEVLIN, S. J. (1988): Locally-weighted regression: an approach to regression analysis by local fitting *Journal of the American Statistical Association* 83 (403): 596–610. https://doi.org/10.2307/2289282

CORVERS, F.–MAYHEW, K. (2021): Regional inequalities: causes and cures *Oxford Review of Economic Policy* 37 (1): 1–16. https://doi.org/10.1093/oxrep/graa067

CUADRADO-ROURA, J. R. (2001): Regional convergence in the European Union: from hypothesis to the actual trends *The Annals of Regional Science* 35 (3): 333–356. https://doi.org/10.1007/s001680100054

DRUKKER, D. D.–EGGER, P.–PRUCHA, I. R. (2013): On two-step estimation of a spatial autoregressive model with autoregressive disturbances and endogenous regressors *Econometric Reviews* 32 (5–6): 686–733. https://doi.org/10.1080/07474938.2013.741020

DURAN, H. E. (2014): Short-run dynamics of income disparities and regional cycle synchronization in the U.S. *Growth & Change* 45 (2): 292–332. https://doi.org/10.1111/grow.12040

DURAN, H. E. (2015): Non-linear regional income divergence and policies: Turkey case *Regional Science Inquiry, Hellenic Association of Regional Scientists* 7 (2): 107–114.

DURBIN, J. (1960): Estimation of parameters in time-series regression models *Journal of the Royal Statistical Society B* 22 (1): 139–153. https://doi.org/10.1111/j.2517-6161.1960.tb00361.x

ECKEY, H. F.–TURCK, M. (2007): Convergence of EU-regions. A literature report *Investigaciones Regionales* 10: 5–32.

EGRI, Z.–TÁNCZOS, T. (2018): The spatial peculiarities of economic and social convergence in Central and Eastern Europe *Regional Statistics* 8 (1): 49–77. http://dx.doi.org/10.15196/RS080108

ELHORST, J. P. (2010): Applied spatial econometrics: raising the bar *Spatial Economic Analysis* 5 (1): 9–28. https://doi.org/10.1080/17421770903541772

ELHORST, J. P. (2014): *Spatial econometrics. from cross-sectional data to spatial panels* Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-40340-8

ELLISON, G.–GLAESER, E. L. (1999): The geographic concentration of industry: does natural advantage explain agglomeration? *The American Economic Review* 89 (2): 311–316. https://doi.org/10.1257/aer.89.2.311

ERK, N.–ATES, S.–DIREKCI, T. (2000): *Convergence and growth within GAP region (South Eastern Anatolia project) and overall Turkey's regions* IV. METU International Congress of Economy. 13–16 September Ankara.

FAN, J.–GIJBELS, I. (1996): *Local polynomial modelling and its application* Chapman & Hall.

FAN, J.–MARRON, J. S. (1994): Fast implementations of nonparametric curve estimators *Journal of Computational and Graphical Statistics* 3 (1): 35–56. https://doi.org/10.2307/1390794

FISHER, R. A. (1922a): On the mathematical foundations of theoretical statistics *Philosophical Transactions of the Royal Society of London. Series A, Containing Papers of a Mathematical or Physical Character* 222: 309–368. https://doi.org/10.1098/rsta.1922.0009

FISHER, R. A. (1922b): The goodness of fit of regression formulae, and the distribution of regression coefficients *Journal of the Royal Statistical Society* 85 (4): 597–612. https://doi.org/10.1111/j.2397-2335.1922.tb00832.x

FOTHERINGHAM, A. S.–BRUNSDON, C.–CHARLTON, M. A. (2002): *Geographically weighted regression: the analysis of spatially varying relationships* Chichester-Wiley.

GEZICI, F.–HEWINGS, G. J. D. (2007): Spatial analysis of regional inequalities in Turkey *European Planning Studies* 15 (3): 383–403. https://doi.org/10.1080/09654310601017091

GROSSMAN, G. M.–HELPMAN, E. (1990): Comparative advantage and long-run growth *American Economic Review* 80(4): 796–815. https://doi.org/10.3386/w2809

GOECKE, H.–HUTHER, M. (2016): Regional convergence in Europe *Intereconomics* 51 (3): 165–171. https://doi.org/10.1007/s10272-016-0595-x

GOMLEKSIZ, M.–SAHBAZ, A.–MERCAN, B. (2017): Regional economic convergence in Turkey: does the government really matter for? *Economies* 5 (3): 27. https://doi.org/10.3390/economies5030027

GUJARATI, D. N.–PORTER, D. C. (2003): *Basic econometrics* 5th edition, Prentice Hall.

GÜLEL, F. E.–ÇAĞLAR, A.–KANGALLI-UYAR, S. G.–KARADENIZ, O.–YEŞILYURT, M. E. (2017): Türkiye'de illere göre insani gelişme endeksi *Pamukkale Üniversitesi Sosyal Bilimler Enstitüsü Dergisi* 27: 208–216. https://doi.org/10.5505/pausbed.2017.99705

GÜLEL, F. E.–EVCIM, N.–YEŞILYURT, M. E. (2021): Türkiye'de il, yil ve cinsiyet kirilimli ortalama ve beklenen okullaşma yili ve il kirilimli insani gelişme endeksi (2009–2019) *Pamukkale Journal of Eurasian Socioeconomic Studies* 8 (2): 70−104. https://doi.org/10.34232/pjess.895689

HARDLE, W. K. (1991): *Smoothing techniques with implementation in S* Springer–Verlag.

HARDLE, W. K. (1992): *Applied nonparametric regression* Econometric Society Monographs, Series Number 19, Cambridge University Press.

ISRAEL, E.−FRENKEL, A. (2018): Social justice and spatial inequality: toward a conceptual framework *Progress in Human Geography* 42 (5): 647−665. https://doi.org/10.1177/0309132517702969

JARQUE, C. M.–BERA, A. K. (1980): Efficient tests for normality, homoscedasticity and serial independence of regression residuals *Economics Letters* 6 (3): 255–259. https://doi.org/10.1016/0165-1765(80)90024-5

JARQUE, C. M.–BERA, A. K. (1987): A test for normality of observations and regression residuals *International Statistical Review* 55 (2): 163–172. https://doi.org/10.2307/1403192

KANBUR, R.−VENABLES, A. J. (Eds.) (2005): *Spatial inequality and development* OUP, Oxford.

KARACA, O. (2018): Türkiye'de bölgesel yakinsamanin 50 yili: yeni veri seti ve 1960–2010 dönem analizi *Sosyoekonomi* 26 (35): 207−228. https://doi.org/10.17233/sosyoekonomi.343016

KARAHASAN, B. C. (2015): Regional inequalities in Turkey: post 2001 era *Marmara University Journal of Economic and Administrative Sciences* 37 (1): 125−147. https://doi.org/10.14780/iibd.83419

KARAHASAN, B. C. (2018): Spatial varying relationship between financial development and new firm formation: evidence from a developing country *Panoeconomicus* 65 (5): 633−675. https://doi.org/10.2298/PAN160125004K

KARAHASAN, B. C. (2020): Winners and losers of rapid growth in Turkey: analysis of the spatial variability of convergence *Papers in Regional Science* 99 (3): 603−644. https://doi.org/10.1111/pirs.12496

KASMAN, A.−TURGUTLU, E. (2009): Testing stochastic convergence among the regions of Turkey *The International Journal of Emerging and Transition Economies* 2 (1): 81–98.

KELEJIAN, H. H.−PRUCHA, I. R. (1998): A generalized spatial two-stage least squares procedures for estimating a spatial autoregressive model with autoregressive disturbances *Journal of Real Estate Finance and Economics* 17: 99−121. https://doi.org/10.1023/A:1007707430416

KELEJIAN, H. H.−PRUCHA, I. R. (1999): A generalized moments estimator for the autoregressive parameter in a spatial model *International Economic Review* 40 (2): 509−533. https://doi.org/10.1111/1468-2354.00027

KELEJIAN, H. H.−PRUCHA, I. R. (2007): HAC estimation in a spatial framework *Journal of Econometrics* 140 (1): 131–154. https://doi.org/10.1016/j.jeconom.2006.09.005

KIRDAR, M. G.–SARACOGLU, D. S. (2012): İç göç, bölgesel yakinsama sorunu ve ekonomik büyüme: Türkiye Örneği *Discussion Paper* 75., Turkish Economic Association.

KOOPMANS, T. C. (1965): On the concept of optimal economic growth. In: *The economic approach to development planning* pp. 225–287., Rand McNally, Chicago.

KRUGMAN, P. (1991): Increasing returns and economic geography *Journal of Political Economy* 99 (3): 483–499. https://doi.org/10.1086/261763

KRUGMAN, P. (1997): *Development, geography, and economic theory* MIT Press, Cambridge, MA.

KRUGMAN, P–VENABLES, A. (1992): *Geography and trade* MIT Press, Cambridge, MA.

LESAGE, J. P. (2008): An introduction to spatial econometrics *Revue D'Economie Industrielle* 123: 19–44. https://doi.org/10.4000/rei.3887

LESAGE, J. P.–PACE, R. K. (2009): *Introduction to spatial econometrics. Statistics: textbooks and monographs* Chapman & Hall/CRC: NW, USA.

LUCAS, R. E. (1988): On the mechanics of economic development *Journal of Monetary Economics* 22 (1): 3–42. https://doi.org/10.1016/0304-3932(88)90168-7

MAGRINI, S. (2004): Regional (DI)Convergence. In: HENDERSON, J. V.–THISSE, J. F. (eds.): *Handbook of regional and urban economics* 4, chapter 62, pp: 2741–2796, Elsevier.

MAGRINI, S.–GEROLIMETTO, M.–DURAN, H. E. (2015): Regional convergence and aggregate business cycle in the United States *Regional Studies* 49 (2): 251–272. https://doi.org/10.1080/00343404.2013.766319

MANKIW, N. G.–ROMER, D.–WEIL, D. N. (1992): A contribution to the empirics of economic growth *Quarterly Journal of Economics* 107 (2): 407–437. https://doi.org/10.2307/2118477

MANSKI, C. F. (1993): Identification of endogenous social effects: the reflection problem *The Review of Economic Studies* 60 (3): 531–542. https://doi.org/10.2307/2298123

MARRON, J. S.–NOLAN, D. (1988): Canonical kernels for density estimation *Statistics and Probability Letters* 7 (3): 195–199. https://doi.org/10.1016/0167-7152(88)90050-8

MAULANA, M. R.–AGINTA, H. (2022): Testing for convergence clubs in real wage across Indonesian provinces from 2008 to 2020. *Regional Statistics* 12 (3): 104–130. https://doi.org/10.15196/RS120305

MORAN, P. A. P. (1950): A test for the serial independence of residuals *Biometrika* 37 (1/2): 178–181. https://doi.org/10.2307/2332162

MYRDAL, G. (1957): *Economic theory and underdeveloped regions* Gerald Duckworth, London.

NADARAYA, E. A. (1964): On estimating regression *Theory of Probability & Its Applications* 9 (1): 141–142. https://doi.org/10.1137/1109020

NEMES NAGY, J.–TAGAI, G. (2011): Regional inequalities and the determination of spatial structure *Regional Statistics* 1 (1): 15–28.

ÖCAL, N.–YILDIRIM, J. (2010): Regional effects of terrorism on economic growth in Turkey: a geographically weighted regression approach *Journal of Peace Research* 47 (4): 477–489. https://doi.org/10.1177/0022343310364576

ÖZKUBAT, G.–SELIM, S. (2019): Türkiye'de illerin sosyo-ekonomik gelişmişliği: bir mekânsal ekonometrik analiz *Alphanumeric Journal* 7 (2): 449–470. https://doi.org/10.17093/alphanumeric.507697

PAEZ, A.–FARBER, S.–WHEELER, D. (2011): A simulation-based study of geographically weighted regression as a method for investigating spatially varying relationships *Environment and Planning A* 43 (12): 2992–3010. https://doi.org/10.1068/a44111

PEKKALA, S. (2000): Aggregate economic fluctuations and regional convergence: the finnish case 1988–1995. *Applied Economics* 32 (2): 211–219. https://doi.org/10.1080/000368400322895

PERROUX, F. (1950): Economic space: theory and applications *Quarterly Journal of Economics* 64 (1): 89−104.

PERROUX, F. (1955): Note sur la notion de poles croissance *Economic Appliquee* 1-2: 307−320.

PETRAKOS, G.–RODRIGUEZ-POSE, A.–ROVOLIS, A. (2005): Growth, integration, and regional disparities in the European Union *Environment and Planning A: Economy and Space* 37 (10): 1837–1855. https://doi.org/10.1068/a37348

PURWONO, R.−YASIN, M. Z.−HAMZAH, I. N.−ARIFIN, N. (2021): Total factor productivity convergence of Indonesia's provincial economies, 2011–2017 *Regional Statistics* 11 (4): 52−78. https://doi.org/10.15196/RS110403

RAMAJO, J.−MÁRQUEZ, M. A.−HEWINGS, G. J. D.−SALINAS, M. M. (2008): Spatial heterogeneity and interregional spillovers in the European Union: do cohesion policies encourage convergence across regions? *European Economic Review* 52 (3): 551−567. https://doi.org/10.1016/j.euroecorev.2007.05.006

RAMSEY, F. P. (1928): A mathematical theory of saving *Economic Journal* 38 (152): 543–559. https://doi.org/10.2307/2224098. JSTOR 2224098

REY, S. J.–MONTOURI, B. D. (1999): US regional income convergence: a spatial econometric perspective *Regional Studies* 33 (2): 143–156. https://doi.org/10.1080/00343409950122945

ROMER, P. M. (1986): Increasing returns and long-run growth *Journal of Political Economy* 94 (5): 1002−1037.

ROMER, P. M. (1987): Growth based on increasing returns due to specialization *The American Economic Review* 77 (2): 56−62.

ROMER, P. M. (1990): Endogenous technical change *Journal of Political Economy* 98 (5): 71−102.

SAGBAS, I. (2002): Türkiye'de kamu harcamalarinin yakinsama üzerindeki etkisi *Afyon Kocatepe Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi* 4 (2): 137−148.

SEN, H.–CEMREK, F.–OZAYDIN, O. (2006): Türkiye'deki illerin sosyo-ekonomik gelişmişlik düzeylerinin belirlenmesi *Sosyal Ekonomik Araştirmalar Dergisi* 6 (11): 155−171.

SIMONOFF, J. S. (1996): *Smoothing methods in statistics* Springer-Verlag.

SOLOW, R. M. (1956): A contribution to the theory of economic growth *The Quarterly Journal of Economics* 70 (1): 65−94. https://doi.org/10.2307/1884513

SWAN, T. W. (1956): Economic growth and capital accumulation *Economic Record* 32 (2): 334−361. https://doi.org/10.1111/j.1475-4932.1956.tb00434.x

TEKIN, A.−DOĞAN, D. (2022): Evaluation of the development level of provinces in Turkey and incentives for research and development. In: BAYAR, Y.–SASMAZ, M. U.–OZTURK, O. F. (eds.): *Technological development and impact on economic and environmental sustainability* pp. 154−167. https://doi.org/10.4018/978-1-7998-9648-7.ch012

TEMEL, T.–TANSEL, A.–ALBERSEN, P. J. (1999): Convergence and spatial patterns in labor productivity: non-parametric estimations for Turkey *Journal of Regional Analysis and Policy* 29 (1): 3−19. https://doi.org/10.22004/ag.econ.130529

UNAL, Ç. (2008): İnsani gelişmişlik endeksine göre türkiye'nin bölgesel farkliliklari *Coğrafi Bilimler Dergisi* 6 (2): 89−113. https://doi.org/10.1501/Cogbil_0000000087

WATSON, G. S. (1964): Smooth regression analysis *The Indian Journal of Statistics* 26 (4): 359–372.

YANIKKAYA, H. (2001): Convergence: a cross country empirical analysis *Yönetim ve Ekonomi* 7 (1): 139−162.

YILDIRIM, J.–ÖCAL, N.–OZYILDIRIM, S. (2009): Income inequality and economic convergence in Turkey: a spatial effect analysis *International Regional Science Review* 32 (2): 221–254. https://doi.org/10.1177/0160017608331250

YILDIRIM, J.–ÖCAL, N. (2013): Analysing the determinants of terrorism in Turkey using geographically weighted regression *Defence and Peace Economics* 24 (3): 195–209. https://doi.org/10.1080/10242694.2012.695034

YOLOĞLU, A. C. (2021): Convergence and intra-regional inequalities in turkey: an evaluation through socio-economic development index at district level *Journal of Planning* 31 (1): 12–30. https://dx.doi.org/10.14744/planlama.2020.88310

INTERNET SOURCES

[1] ANSELIN, L. (2003): *GeoDa™ 0.9 User's Guide.* https://geodacenter.github.io/docs/geoda093.pdf (downloaded: April 2023)

[2] ANSELIN, L.–REY, S. (2014): *Modern spatial econometrics in practice: a guide to GeoDa, GeoDaSpace and PySAL.* https://sergerey.org/giasp16/pdfs/anselin_rey_weights.pdf (downloaded: April 2023)

[3] BIVAND, R.– ALTMAN, M.–ANSELIN, A.–ASSUNÇÃO, R.–BERA, A.–BERKE, O.–BLANCHET, F. G.–CARVALHO, M.–CHRISTENSEN, B.–CHUN, Y.–DORMANN, C.–DRAY, S.–DUNNINGTON, D.–GÓMEZ-RUBIO, V.–KOLEY, M.–KRAINSKI, E.–LEGENDRE, P.–LEWIN-KOH, N.–LI, A.–MILLO, G.–MUELLER, W.–ONO, H.–PARRY, J.–PERES-NETO, P.–PIRAS, G.–REDER, M.–SAUER, J.–TIEFELSDORF, M.–WESTERHOLT, R. (2023a): R *Spdep package.* https://cran.r-project.org/web/packages/spdep/spdep.pdf (downloaded: June 2024)

[4] BIVAND, R.–YU, D.–NAKAYA, T.–GARCIA-LOPEZ, M.-A. (2023b): R *Spgwr package.* https://cran.r-project.org/web/packages/spgwr/spgwr.pdf (downloaded: June 2024)

[5] BIVAND, R.– PIRAS, G.–ANSELIN, L.–BERNAT, A.–BLANKMEYER, E.–CHUN, Y.–GÓMEZ-RUBIO, V.–GRIFFITH, D.–GUBRI, M.–HALBERSMA, R.–LESAGE, J.–LI, A.–LI, H.–MA, J.–MALLIK, A.–MILLO, G.–PACE, K.–PERES-NETO, P.–RÜTTENAUER, T.–SARRIAS, M.–SAYAGO, J.–TIEFELSDORF, M. (2023c): R *Spatialreg package.* https://cran.r-project.org/web/packages/spatialreg/spatialreg.pdf (downloaded: June 2024)

[6] FILIZTEKIN, A. (1999): *Convergence across Turkish provinces and sectoral dynamics.* https://myweb.sabanciuniv.edu/alpayf/files/2010/04/provconv.pdf (downloaded: April 2023)

[7] HERRERA GOMEZ, M.–MUR LACAMBRA, J.–RUIZ MARIN, M. (2012): Selecting the most adequate spatial weighting matrix: a study on criteria *MPRA Working Paper* No. 73700. https://mpra.ub.uni-muenchen.de/73700/1/MPRA_paper_73700.pdf (downloaded: April 2023)

[8] KARACA, O. (2004): Türkiye'de bölgeler arasi gelir farkliliklari: yakinsama var mi? *Türkiye Ekonomi Kurumu tartişma metni* 2004/7. https://www.tek.org.tr/pdf/769_9122022_210507.pdf (downloaded: April 2023)

[9] KRUGMAN, P. (1990): Increasing returns and economic geography *Working Paper* No 3275. NBER Working Paper Series. https://www.nber.org/system/files/working_papers/w3275/w3275.pdf (downloaded: April 2023)

DATABASES/WEBSITES

[10] EMAD Energy: *İllerin Dilim Orta Meridyenleri (Boylamlari).* https://www.emadenerji.com/wp-content/uploads/2019/09/I%CC%87llerin-Dilim-Orta-Meridyenleri.pdf (downloaded: April 2023)
[11] Ministry of Transport and Infrastructure, General Directorate of Highways: www.kgm.gov.tr (downloaded: April 2023)
[12] Ministry of Industry and Technology, General Directorate of Development Agencies, Republic of Türkiye (2017): *İllerin ve bölgelerin sosyo-ekonomik gelişmişlik siralamasi araştirmasi SEGE-2017*. https://www.sanayi.gov.tr/merkez-birimi/b94224510b7b/sege/il-sege-raporlari (downloaded: April 2023)
[13] State Planning Organization, Prime Ministry of Turkey (1969): *Türkiye'de İller İtibariyle Sosyo Ekonomik Gelişmişlik Endeksi SEGE-1969* (Ministry of Industry and Technology). https://www.sanayi.gov.tr/merkez-birimi/b94224510b7b/sege/il-sege-raporlari (downloaded: April 2023)
[14] www.datawrapper.de (downloaded: April 2023)
[15] UNDP: https://www.undp.org/sites/g/files/zskgke326/files/migration/tr/UNDP-TR-TECHNICAL-NOTES-HDI-IHDI-HDR-2020-EN.pdf (downloaded: April 2023)
[16] Eviews 4 User's Guide (2002)
[17] TUIK: www.tuik.gov.tr