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# Validity of Okun's Law in a Spatially Dependent and Cyclical Asymmetric Context

**Summary:** The current article analyzes the validity of Okun's Law and sizable distortions that can occur in the estimation when spatial dependence and cyclical asymmetric impacts are not considered, which is a concern commonly ignored by the existing literature. Primarily spatial panel regressions (SDM, SAR, and SEM) and nonparametric regressions along with specification tests are adopted in terms of the methodology (such as panel unit root tests, panel cointegration, Moran's I and Geary's C tests of global spatial dependence, spatial LM, and Hausman tests). Additionally, spatial heterogeneity and cross-regional variation in Okun's Law are investigated by adopting geographically weighted regression, LISA (local indicators for spatial association), and local Geary's C analysis. A panel of 26 Turkish NUTS-2 regions from 2004 to 2018 was analyzed. The results clearly revealed that failing to incorporate spatial proximity and asymmetric cycle impacts leads to the biased estimation of Okun's coefficient, such that during the downswing years of the national economy, Okun's Law holds robustly: unemployment increases quickly in response to a decline in output. In contrast, during upswing years, the size of Okun's coefficient is relatively much lower. Moreover, spatial dependence and heterogeneity are sizably evident. Okun's coefficient is demonstrated to vary significantly across regions that have different industrial and labor market characteristics. As a policy implication, it has been understood that the reduction of unemployment is more difficult than initially understood, as economic growth itself does not provide a solution during upswing periods. The necessary special and region-specific policies are discussed throughout the text.

**Keywords:** Okun's law, Spatial regression, Cyclical asymmetry.

**JEL:** E24, E32, R15.

In macroeconomics literature, Okun's Law has widely been recognized as a rule that indicates a direct association between output and unemployment (Arthur M. Okun 1962; Robert J. Gordon 1984; Charles Adams and David T. Coe 1990). It claims the necessity of a 3% output growth to reduce 1 point the unemployment rate (Okun 1962).

However, severe methodological drawbacks must be considered in this field. First, existing studies have often failed to consider the spatial economic interconnections among the regions of the country, the ignorance of which might lead to severe bias or the overestimation/underestimation of Okun's coefficient (Reinhold Kosfeld and Christian Dreger 2006; Christian Oberst and Jens Oelgemöller 2013). Second, the literature has often considered the output-unemployment relationship as a symmetric and constant fact that does not vary over the business cycle phases (Aki Kangasharju, Christope

Tavéra, and Peter Nijkamp 2012). However, economic downturns and booms might have distinguished impacts on unemployment that must be considered when estimating Okun's Law.

The primary objective of the current study is to test Okun's Law for Turkey, by incorporating the methodological innovations explained above. Specifically, the addressed research questions are the followings: Does Okun's Law hold in Turkey? Does the Okun's coefficient change according to the phases of the business cycle (upswing and downswing years)? Is spatial dependence relevant to Okun's Law estimation? Is there a spatial heterogeneity in variables and Okun's Law?

The data set covered a period from 2004 to 2018 and 26 NUTS-2 level regions. The data set analyzed in this article was provided by the Turkish Statistical Institute and the Turkish General Directorate of Highways. Many different spatial and econometric methods were applied.

The remaining parts of this article were structured as follows. In Section 1, a detailed literature survey is provided. In Section 2, empirical analysis is pursued by explaining the data set, methods, and results. Afterward, Section 3 provides a policy discussion. Finally, a conclusion is presented in the last section.

## 1. Literature Review

In the literature on macroeconomics, Okun's Law has been investigated both theoretically and empirically.

### 1.1 Theoretical Background

In theoretical terms, the claimed rationale behind Okun's Law relies on the following consideration: When firms face higher demand for goods and services, they tend to increase their production and employment rather than increase their prices. These changes in price do not occur immediately because of menu costs and other rigidities (Kosfeld and Dreger 2006). Hence, employment is expected to increase following a rise in output.

However, another strand of scholars has supported the opposite view: Okun's Law might not always hold true, because an increase in gross domestic product (GDP) cannot always create employment, termed as *jobless recovery* (Mark Schweitzer 2003). This likely occurs when a substitute for labor-capital is more intensively used in production processes (Salih Barışık, İsmail Emrah Çevik, and Nükhet Kırcı Çevik 2010; Oberst and Oelgemöller 2013). In such a case, capital intensive industries grow faster than labor-intensive ones, which hampers the reduction of the unemployment rate (Barışık, Çevik, and Çevik 2010; Oberst and Oelgemöller 2013). Thus, in some cases, the industrial mix becomes critical. In economic environments in which job-creating dynamic sectors are present, Okun's Law is more likely to hold (Barışık, Çevik, and Çevik 2010; Oberst and Oelgemöller 2013).

Another possible reason for jobless recovery might be the rigidities in the labor market that mitigate positive responses of employment to output growth (Dimitris K. Christopoulos 2004; Oberst and Oelgemöller 2013; Amy. Y Guisingera et al. 2018). Within the systems in which labor market legislation is strict, hiring new employees and replacing them with alternative ones are more costly because of the intensity of protective regulations. In such a case, an increase in investments and GDP does not properly create employment.

Another reason for jobless growth can be driven by massive in-migrating received by developed regions during high growth times. This increases the labor supply and can create an obstacle against the reduction of unemployment.

Moreover, to discuss broad ideas regarding the reasons for unemployment, some structural problems have been presented as the reason behind high unemployment. First, the excess labor supply and intensity of the young population are considered to be important (Sanders Korenman and David Neumark 2000; Ramon Gomez-Salvador and Nadine Leiner-Killinger 2008). Hence, it might well be the case that, during crises, young labor supply is much more easily fired, and experienced workers are preferred. Thus, during recessionary times, special programs for the young labor force should be developed, and the employment of this group should be encouraged (Niall O'Higgins 1997; Gomez-Salvador and Leiner-Killinger 2008). The second reason pertains to the rigidity of the labor market. Because labor market legislation is strict, the turnover of jobs is quite limited, which hampers possible matches among job seekers and employers (Korenman and Neumark 2000; Neumark and William Wascher 2004). Another reason pertains to the transformation of an agriculture-based employment structure into an industry/service economy during recent years. Hence, a massive agricultural labor force remains jobless (Hasan Engin Duran 2019). Controversially, within the systems for which the labor market is flexible, less unemployment is observed, because the mismatch and related frictional problems are lower (Korenman and Neumark 2000; Neumark and Wascher 2004).

Accuracy in the estimation of Okun's Law is politically crucial. The existence of bias might lead to misleading policy implications. For instance, the overestimation of Okun's coefficient during boom years draws a highly optimistic policy scenario that, in such a case, economic growth generates high employment, and thus, no further special policy programs are required to reduce unemployment. In a similar vein, the underestimation of Okun's coefficient during slump periods draws another optimistic scenario regarding unemployment. Hence, focusing on this issue is relevant from both a methodological and political standpoint.

If the law is true, reducing the unemployment rate is easier; in that case, it is sufficient only to increase investments and GDP to reduce the unemployment rate (Christopoulos 2004). However, if the law does not hold (or weakly holds), the unemployment problem becomes a more difficult issue to address. In such case, it takes a persistent, structural, and long-term form, the reduction of which requires special policies, such as structural reforms, heterodox-type interventions, employment programs subsidies, tax exemptions, wage flexibility, the foundation of employment agencies, and policies targeted to relax labor market rigidities (Christopoulos 2004; Jose Villaverde and Adolfo Maza 2007, 2009). Moreover, the validity of Okun's Law might differ among business cycle phases, which indicates the necessity of phase-specific policies.

## 1.2 Empirical Studies

On empirical grounds, a set of studies tested Okun's Law by using one of the following equations (Okun 1962; Gordon 1984; Adams and Coe 1990; Imad A. Moosa 1997):

$$y - y^* = -\beta\,(u - u^*) \quad \text{or} \quad u - u^* = -\varphi\,(y - y^*), \quad \beta = \frac{1}{\varphi}, \tag{1}$$

where $y$ denotes GDP, $y^*$ is its equilibrium level (potential GDP), $u$ represents unemployment, and $u^*$ is its natural rate. Here, $\varphi$ is known as Okun's coefficient, which represents the degree to which the output growth reduces unemployment. A higher $\varphi$ (lower $\beta$) indicates stronger validity of Okun's Law, and in that case, economic growth generates more employment. Controversially, low values of $\varphi$ imply a weak linkage between output gap and unemployment gap.

Historically, Okun (1962) first verified the relationship of his study to the United States. He found the necessity of a 3% output growth to reduce 1 point the unemployment rate ($\beta = 3 \; or \; \varphi = 0.33$ ). This was later tested by others, who found many mixed levels (Gordon 1984; Adams and Coe 1990). For instance, Moosa (1997) analyzed Okun's Law for different countries (from 1960 to 1995) and found quite different results, such as the United States ($\varphi = 0.45$), Japan ($\varphi = 0.08$), Germany ($\varphi$ = 0.40), France ($\varphi$ = 0.36), the UK ($\varphi$ = 0.37), Italy ($\varphi$ = 0.18), and Canada ($\varphi$ = 0.49). Similarly, Martin F. J. Prachowny (1993) analyzed the issue for the United States, Clifford L. F. Attfield and Brian Silverstone (1998) for the United Kingdom, and Jim Lee (2000) for 16 OECD (Organization for Economic Co-operation and Development) countries.

In this field, fewer empirical studies exist for developing/less developed economies. For instance, Zidong An et al. (2017) analyzed the issue for many (25) less developed Asian and African countries for periods corresponding to the 1990-2015 interval. As a result, whereas it holds in half of the countries (i.e., Belize, Bolivia, Eygpt, Honduras, India, Kenya, Mongolia, Morocco, Nicaragua, Philippines, Tajikistan, Tanzania, Turkmenistan, and Uzbekistan), it fails in others. Guilherme Alexandre Tombolo and Marcos Minoru Hasegawa (2014) analyzed the law for the Brazilian economy for the period from 1980 to 2003, in which Okun's coefficient was found as $\varphi = (1/\beta)$ = 0.2.

## 1.3 Okun's Law Regional Studies

Several scholars have attempted to estimate Okun's Law by using regional data. For instance, Donald Freeman (2000) estimated $\beta$ to be approximately 2.22 for US regions during the period from 1977 to 1997. Similarly, Nicholas Apergis and Anthony Rezitis (2003) found $\beta$ for Greek regions to be approximately 1.5 (between 1960 and 1997), Villaverde and Maza (2009) for Spanish regions approximately 0.11 to 1.55 (between 1980 and 2004), and Guisingera et al. (2018) for US states approximately 1.25 to 4.38 (between 1972 and 2012). Most of these studies found considerable regional variation in Okun's coefficient. Far fewer studies have, however, considered spatial dependence and economic spillovers across regions in this context. Some exceptional studies include Kosfeld and Dreger (2006) and Oberst and Oelgemöller (2013).

## 1.4 Okun's Law Studies on Turkey

The study location is interesting and relevant, because Turkey is an emerging economy for which unemployment is one the most severe and chronic economic and social problems. To speak broadly regarding the Turkish economic structure and its unemployment problem, it is an economy that primarily specializes in services and industry. Historically, it has been experiencing an economic transition since the 1980s to date from a more closed economic structure specialized in agriculture toward an internationally open economy specializing in the service sector, industry, and construction (Utku Utkulu 2001).

Unemployment in Turkey is such a severe problem that has not been reduced in recent decades. It has recently exceeded 10%, which is high enough to create social and economic problems, such as the loss of a productive labor base, the social exclusion of unemployment groups, and so on. The reasons for unemployment are a high labor supply, jobless economic growth, disability of some specialized sectors in employment creation, and infeasibility of agriculture the sector, which leads to the migration of unqualified workers to urban areas (Alpay Filiztekin 2009; Duran 2019).

Moreover, Turkey is a developing country that includes diverse and uneven regional economic structures. There is sizable regional economic asymmetry in income, development, and employment (Ferhan Gezici and Geofrey J. D. Hewings 2007; Burhan Can Karahasan 2015, 2017, 2020). These differences are primarily driven by a lack of investments, productive labor force, and specialization in dynamic industries in backward regions. Overall, our study location makes for an interesting setting.

The regional studies on Turkey have focused largely on the income disparities and the tendency toward convergence across regions. Empirically, quite mixed results have primarily been found on the tendency of income disparities for the period prior to 2000 and the significance of spatial income inequalities has often been emphasized and is argued to arise because of the inadequacy of investments, market potential, human capital, firm formation, and social and physical infrastructure in lagging regions (see for some examples of these studies, Gezici and Hewings 2007; Jülide Yıldırım, Nadir Öcal, and Süheyla Özyıldırım 2009; Karahasan 2015, 2017, 2018; Karahasan, Fatma Doğruel, and Ali Suut Doğruel 2016).

The spatial dimension of disparities is presented and discussed also for the post-2000 era. Some valuable examples include Karahasan (2015), who analyzed the 2003-2008 period and found spatial polarization across NUTS-2 regions; Karahasan (2017), who found increasing spatial heterogeneity and persistent inequalities during the 2004-2014 period; Karahasan (2020), who found spatially heterogeneous convergence patterns during the 2004-2017; Duran and Umut Erdem (2017), who found the declining disparities conditioned upon the export orientation of less developed regions; and Tayyar Doğan and Ahmet Kındap (2019), who analyzed the 2004-2011 period and found procyclical disparities, decreasing during recessions and increasing during expansions.

Regarding the regional evolution of unemployment in Turkey, Filiztekin (2009) provides valuable insights. The provincial (urban parts and aggregate province) unemployment disparities and their determinants during the 1980-2000 period were analyzed in this study. It was found that these disparities are sizable and tend to increase and become persistent across provinces. Moreover, labor supply factors (i.e., population density) are found to be an important determinant of these patterns, along with the crucial role played by human capital. His other studies related to Turkey's regional inequalities are Filiztekin and Murat Alp Çelik (2010) and Filiztekin (2015). Moreover, Duran (2019) studied unemployment disparities across 26 NUTS-2 regions in Turkey during the period from 2004 to 2017. Similar to the study by Filiztekin (2009), it was found that unemployment disparities tend to intensify over time. In particular, some regions and subgroups (i.e., age and education) have extreme rates of unemployment, whereas others have lower values. In terms of determinants of the evolution of unemployment, supply-side factors are again found to be the major determinant. Examining from a more sectoral perspective, Pelin Akçagün, Öcal, and Yıldırım (2013) analyzed the regional and sectoral disparities in unemployment during the period from 2004-2011. They found large disparities and convergence of unemployment in the services sector, nonconvergence in the industry sector, and a diverging pattern in the agriculture sector. Similar findings pointing to persistence in regional disparities of unemployment were found by Giray Gözgör (2012).

Regarding the studies concerning the validity of Okun's Law in Turkey at the aggregate level, on the one hand, some studies oppose Okun's Law. For instance, Hakan Acaroğlu (2018) examined Okun's Law during the 1991-2014 period and found no safe evidence of validity. Ferhat Pehlivanoğlu and Marvin Tanga (2016) analyzed the issue during the 1990-2014 period; having applied the Granger cointegration test and fully modified OLS regressions, no evidence for Okun's Law was found. Özer Arabacı and Rabihan Yüksel Arabacı (2018) achieved similar results for the 2001-2013 period, whereas Hüseyin Mualla Yüceol (2006) found no long-term relationship for the 1950-2004 period. Meanwhile, Barışık, Çevik, and Çevik (2010) focused on the 1988-2009 period and found $\beta = 0.74$ for expansions and $\beta = 5.2$ for recessions.

On the other hand, relatively fewer studies support Okun's Law. One example is Uğur Korkut Pata, Süleyman Yurtkuran, and Adem Kalca (2018), who analyzed the 2006-2014 period and found a one-way causality from GDP to unemployment, hence revealing the validity of Okun's Law.

Our proposed contribution to the literature is threefold.

First, thus far in the studies, the aggregate economy has been considered a homogenous unique system, whereas the subnational regional economies and their spatial interconnections have largely been ignored. Ignoring such a factor might, indeed, lead to severe bias and the overestimation/underestimation of Okun's coefficient, as it does not consider the spatial externalities across regions. Indeed, regions are not isolated economic units; there are economic linkages such as trade, investment flows, migration, commuting patterns, and so on. Hence, when a region grows economically, it might create employment growth in neighboring regions, thereby decreasing the unemployment rate (Martin Armstrong and Jim Taylor 2000; James P. LeSage 2008; Luc Anselin and Daniel Arribas-Bel 2013).

Second, the literature has often ignored the possible nonlinear/asymmetric impact of GDP growth on unemployment. However, the phases of economic activity and upswing and downswing years are likely to have distinguished effects on unemployment. During downswing years, it is likely that firms greatly fire workers if the local labor market is sufficiently flexible. During upswing years, this relationship is likely to be less obvious, as it takes time for companies to employ new workers, or it is the result of other labor market rigidities. Such nonlinearities have been investigated and verified by Jesus Crespo-Cuaresma (2003), Paramsohty Silvapulle, Moosa, and Mervyn J. Silvapulle (2004), although never in a regional and spatially interdependent context. Moreover, to our knowledge, current paper is one of the first attempts to analyze Okun's Law by incorporating both spatial dependence and cyclical asymmetric effects in the world literature (an exceptional study; Kangasharju, Tavéra, and Nijkamp 2012).

Third, the current article is one of the first studies to analyze (in Turkey case) Okun's Law at the regional scale although there exist other studies at the national level.

## 2. Empirical Analyses

The empirical analysis is composed of five subsections. This section is divided as follows: First, it is implemented as a descriptive analysis by providing summary statistics, charts, and the methods of calculation of the variables to obtain a preliminary understanding. Second, panel unit root and cointegration analyses are performed to understand the time-series features of variables. Third, global and local spatial dependence analyses are performed to understand the severity of spatial dependence. Spatial autocorrelation analysis was performed by using Global Moran's *I* and Geary's *C*. Local indicators for spatial association (LISA) and local Geary's *C* were implemented to explore the spatial heterogeneity. Fourth, Okun's Law is estimated by selecting the proper spatial panel regression separately for upswing and downswing years. Finally, a geographically weighted regression (GWR) analysis is pursued to estimate the region-specific Okun's coefficient.

### 2.1 Data Processing and Descriptive Analyses

In our empirical analyses, we use the following form of Okun's Law:

$$u - u^* = -\varphi\,[(y - y^*) \times 100]. \tag{2}$$

Two types of variables were used in our empirical analyses: GDP ($y$, in natural logarithms) and unemployment rates ($u$). The GDP variable is deflated by using regional consumer price indexes (provided by Central Bank of the Republic of Turkey 2018)[1].

To provide descriptive information before proceeding with the analysis, Table 1 documents the summary statistics concerning the average rate of unemployment and average yearly GDP growth in regions.

Cross-regional and period average unemployment is 10.1%, whereas the standard deviation is quite high (4.4). Similarly, the mean GDP growth is 3.3% per annum, whereas its standard deviation is substantially high.

In both variables, we observe sizable variation across regions, implying a spatially varying Okun's Law. Therefore, the incorporation of the spatial dimension is crucial for this study; this further motivates us to study this issue.

[1] **Central Bank of the Republic of Turkey.** 2018. www.tcmb.gov.tr (accessed December 05, 2018).

**Table 1** Descriptive Statistics

| Region | Period average unemployment rate | Annual average GDP growth |
|---|---|---|
| TR10 | 12,5 | 4,9 |
| TR21 | 8,5 | 5,0 |
| TR22 | 6,4 | 3,6 |
| TR31 | 14,1 | 4,3 |
| TR32 | 8,6 | 3,9 |
| TR33 | 6,5 | 4,4 |
| TR41 | 8,9 | 5,1 |
| TR42 | 11,5 | 6,3 |
| TR51 | 11,9 | 3,9 |
| TR52 | 7,9 | 4,7 |
| TR61 | 9,0 | 4,1 |
| TR62 | 14,1 | 4,2 |
| TR63 | 14,1 | 5,2 |
| TR71 | 10,0 | 4,1 |
| TR72 | 10,8 | 3,5 |
| TR81 | 7,9 | 4,6 |
| TR82 | 6,7 | 3,0 |
| TR83 | 6,8 | 3,3 |
| TR90 | 5,8 | 4,2 |
| TRA1 | 5,8 | 4,1 |
| TRA2 | 6,0 | 3,6 |
| TRB1 | 11,9 | 4,2 |
| TRB2 | 11,7 | 4,6 |
| TRC1 | 13,5 | 5,5 |
| TRC2 | 13,8 | 4,3 |
| TRC3 | 18,3 | 6,1 |
| Mean | 10,1 | 4,4 |
| SD | 3,3 | 0,8 |

**Source:** Own calculations.

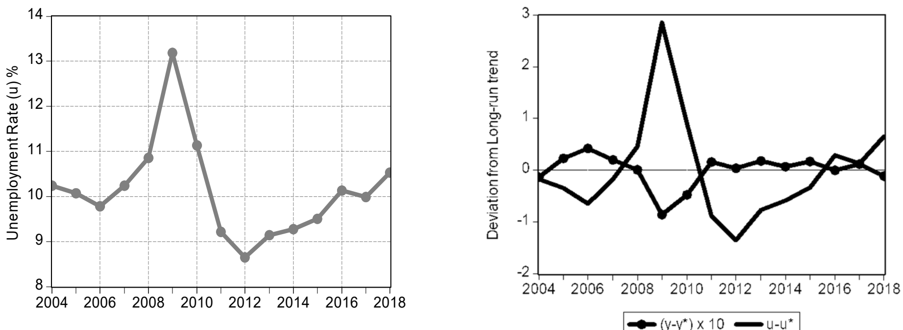
If we consider the most and least problematic regions in terms of unemployment, Southern regions (TR62, TR63, and TRC1) and one Aegean region (TR31) specialized primarily in trade (TRC1, TR31), tourism (TR62), and industry (TR63) have, respectively, the highest unemployment rates (14.1%, 14.1%, 18.3%, respectively), whereas Northeast regions (TR90, TRA1, TRA2), mostly specialized in agriculture/horticulture, have the lowest unemployment rates (5.8%, 5.8%, and 6%, respectively). These northeastern regions are subject to massive out-migration. They possibly lose their labor force, and therefore, unemployment appears to be lower, as the labor force is low as well. Regarding the explanation of high unemployment in Southern regions, the sectoral structure and characteristics of the services and industry sectors are responsible (as discussed further in the policy discussion part). Concerning the geographical distribution of economic growth, the most rapidly growing regions are TR42, TRC1, and TRC3, with an annual rate of 6.3%, 5.5%, and 6.1%, respectively, whereas the slowest growing regions are TR82, TR83, and TR72, with corresponding rates of 3.0%, 3.3%, and 3.5%, respectively. The regions with the best performance are either industrial zones (TR42) or relatively low-income areas with less accumulated capital per capita, in line with the New Classical growth theory (Robert M. Solow 1956). The slowest growing regions are generally the Middle/Northern Anatolian regions, which have mixed sectoral composition.

To provide further descriptive analysis of the national data, Figure 1a depicts the evolution of the unemployment rate in Turkey. It represents, in general, an evolution of approximately 10% to 11% unemployment rate. It exhibits a quite anticyclical evolution, depending on the domestic and international economic circumstances.

Considering the recent evolution, unemployment was low, approximately 8% during the 2004-2006 period, primarily driven by high growth in the world (due to expansionary monetary policies) and in Turkey. However, it reached 13% during the 2008/2009 Global Financial crisis, lowered to 9% by 2013, and then rose again and reached 10.5% in 2018. Together with the turmoil and slowdown of the economic growth, the unemployment problem has become more severe. Although the economy had high economic growth in 2017, by 2018, the depreciation of the Turkish Lira against other currencies, the rise in the interest rate, and inflation lowered investments and led to negative economic growth.

In addition to the low economic growth, other structural reasons for such an unemployment problem should be discussed theoretically. In neoclassical/liberal world circumstances (i.e., post-1980), given the transition of the economy from agriculture to an industrial- and service-based digital economy, a considerable mass of the agricultural labor force remains jobless. The urbanization and migration of workers from agricultural rural areas to urban areas are among the potential reasons for high unemployment (Korenman and Neumark 2000; Gomez-Salvador and Leiner-Killinger 2008; Filiztekin 2009; Duran 2019). The rigidity of the labor market and frictional problems, such as a mismatch and lack of desired technically skilled workers, are among the crucial reasons for unemployment in Turkey (Korenman and Neumark 2000; Gomez-Salvador and Leiner-Killinger 2008; Filiztekin 2009; Duran 2019).

The national evolution of the GDP gap ($y - y^*$) and unemployment ($u - u^*$) is depicted in Figure 1b.




(1.a.) Unemployment Rate

(1.b) GDP ((y – y*) x 10) and Unemployment Gap (u – u*)

**Source:** Turkish Statistical Institute (2018)[2].

**Figure 1** Plot of GDP and Unemployment Gaps (GDPx10 Rescaled)

[2] **Turkish Statistical Institute.** 2018. www.tuik.gov.tr (accessed December 05, 2018).

Calculation of the equilibrium level of variables $(u^*, y^*)$ is not immediate. In the literature, various filtering (trend smoothing and business cycle extraction) methods, such as those used in Marianne Baxter and Robert G. King (1999) and Lawrance J. Christiano and Terry J. Fitzgerald (2003), have been applied to estimate the long-term potential GDP $(y^*)$ and unemployment natural rate $(u^*)$.

We prefer to use the detrending technique of Robert Hodrick and Edward Prescott (HP) (1997), as it is simple, intuitive, and largely applied in the literature. This filter has some merits and concerns regarding the accuracy of timing, amplitude, and frequency of the cyclical phases. However, it is widely used in the literature and is among the relatively most successful filters.

Specifically, given that $y$ is a time-series variable of interest, the HP filter tries to minimizes the following term:

$$\min \sum_{t=1}^{T} (y_t - y_t^*)^2 + \emptyset \sum_{t=2}^{T-1} [(y_{t+1}^* - y_{t)}^*{}_- (y_t^* - y_{t-1}^*]^2, \quad (3)$$

where $y$ is the actual GDP in natural logarithms, $y_t^*$ is a trend term that captures the long-term equilibrium level and potential GDP, and $\emptyset$ is a parameter of the trend smoothness. For the annual data, we set $\emptyset = 100$, as commonly applied in the literature (The HP filter formula in Equation (3) and related parameters were adapted from Hodrick and Prescott 1997; Duran 2013, 2015).

## 2.2 Panel Unit Root and Cointegration Analyses

An important step in empirical analysis is to understand the unit root and stationarity features of the variables. To do so, we apply five different panel unit root tests: Augmented Dickey Fuller-Fisher test (Fisher-ADF), Philips Perron-Fisher (Fisher-PP), a $\chi^2$ test (Ronald A. Fisher 1932; Gangadharrao S. Madalla and Shaowen Wu 1999; In Choi 2001), and those developed by Andrew Levin, Chen-Fu Lin, and James Chia-Shang Chu (2002) and Kyung So Im, M. Hashem Pesaran, and Yongcheol S. Shin (2003).

Specifically, the logic behind most panel unit root tests relies on the following specification (Fisher 1932; Madalla and Wu 1999; Choi 2001; Levin, Lin, and Chu 2002; Im, Pesaran, and Shin 2003):

$$x_{i,t} = \rho_i x_{i,t-1} + Z_{i,t}\delta_{i,t} + e_{i,t}, \quad (4)$$

where $i$ denotes the units of cross-sections, $t$ shows a time index. Moreover, $Z$ contains exogenous variables, such as region fixed effects or individual trends, and $e_{i,t}$ represents the independently and identically distributed idiosyncratic disturbance term.

Statistically, if $\rho_i = 1$, a unit root process is present that indicates a nonstationary property, whereas $\rho_i < 1$ indicates a stationary evolution.

Regarding the differences in specifications across methods, Levin, Lin, and Chu (2002) adopted a parameter common for all regions, $\rho_i = \rho$ . Alternatively, a unit root process may be allowed to vary across regions $(\rho_i)$; in such a case, each region has a different $\rho$ value. Im, Pesaran, and Shin (2003), Fisher-ADF, and Fisher-PP adopt the latter specification (for further technical details of the test specifications, see Fisher 1932; Madalla and Wu 1999; Choi 2001; Levin, Lin, and Chu 2002; Im, Pesaran, and Shin 2003).

The last test is CADF (cross-sectionally augmented Dickey-Fuller), which also considers the cross-sectional dependence among regions (Im, Pesaran, and Shin 2003; Pesaran 2007).

The results are documented in Table 2 below. It is observed that $y$ is nonstationary, whereas $u$ is stationary. Once we detrend the two variables by using the HP (1997) filter, all variables ($u - u^*$ and $y - y^*$) become stationary.

**Table 2** Panel Unit Root Tests

| Test Type | Levels | | Hodrick-Prescott detrended | |
|---|---|---|---|---|
| | *u* | *y* | *u-u** | *y-y** |
| Levin, Lin, and Chu test (T-statistic) | -5,4839*** | -0,02231 | -16,3803*** | -12,2551*** |
| Im, Pesaran, and Shin test (W-statistics) | -4,20993*** | 6,07176 | -11,7508*** | -10,1556*** |
| ADF Fisher Chi-square (Chi-square stat) | 97,3076*** | 7,5597 | 222,709*** | 194,017*** |
| PP - Fisher Chi-square (Chi-square stat) | 89,8641*** | 7,67872 | 183,656*** | 216,705*** |

**Notes:** *** shows statistical significance at 1%, ** at 5 %, * at 10 % (this classification is also valid for the remaining parts of the paper). Lag length was determined on Akaike Information Criterion basis (Akaike 1973), maximum lag length = 2, levels of the variables are used in test where individual intercepts are allowed.

**Source:** Own calculations.

As $u$ is stationary and $y$ is nonstationary in levels, the possibility of a long-term cointegrating relationship should be investigated. Technically, cointegration tests work as follows (Robert F. Engle and Clive W. J. Granger 1987; Peter Pedroni 1999; 2004):

$$x_{i,t} = \partial_i + \gamma_i t + \theta_1 v_{1\,i,t} + \cdots + \theta_n z_{n,i,t} + \epsilon_{i,t}, \tag{5}$$

where $i$ represents regions, and $t$ represents time. The two nonstationary variables ($I(1)$) are $x$ and $v$. The regression includes a region-specific constant term ($\partial_i$) and time trends ($\gamma_i t$). If the error terms ($\epsilon_{i,t}$) follow a nonstationary, $I(1)$, process, no cointegration is present. In contrast, if errors are stationary, a cointegration and long-term relationship exist between $x$ and $v$ (Fisher 1932; Johansen Søren 1991).

Ho: no cointegration $\epsilon_{i,t}$ is nonstationary, $I(1)$.
Ha: cointegration, $\epsilon_{i,t}$ is stationary, $I(0)$.

Individual intercepts and trend components may be used or discarded from tests. In the decision, trace and maximum Eigen statistics and $\chi^2$ tests are used. Within the procedure of the test, bivariate vector autoregression equations are applied, in which time lag length is determined on the Akaike criterion basis (max.lag = 2 years) (Hirotugu Akaike 1973).

The results are presented in Table 3. When no individual intercepts or trends are included, two cointegrating equations are evident. When intercepts are allowed, this results in only one cointegrating relationship. Finally, when linear or quadratic time trends and intercepts are allowed, no cointegrating relationships are found.

Overall, technical properties indicate that no robust long-term cointegrating relationship exists between $u$ and $y$. Hence, it is plausible to proceed to the analysis with detrended stationary output ($y - y^*$) and unemployment gaps ($u - u^*$).

**Table 3** Johansen Panel Co-integration Test Results

| Trend type | No | No | Linear | Linear | Quadratic |
|---|---|---|---|---|---|
| Type of test: | Constant: No Trend: No | Constant: Yes Trend: No | Constant: Yes Trend: No | Constant: Yes Trend: Yes | Constant: Yes Trend: Yes |
| Number of co-integrating equations trace statistics | 2 | 1 | 0 | 0 | 0 |
| Number of co-integrating equations max-eigen values | 2 | 1 | 0 | 0 | 0 |

**Notes:** VAR Analysis was implemented initially. Lag length was determined on Akaike Information Criterion basis, maximum lag length = 2, critical values were given by MacKinnon-Haug-Michelis (James MacKinnon, Alfred Haug, and Leo Michelis 1999) at 5 % level.

**Source:** Own calculations.

## 2.3 Spatial Dependence and Global and Local Spatial Dependence Analyses

The spatial properties of data are crucial in regional studies. It is essential to explore the existence and nature of spatiality, as it provides many insights into the nature of the problem searched and helps in selecting the correct spatial model.

Initially, we applied global spatial dependence tests to our variables. These were of two types: Global Moran's *I* (Patrick A. P. Moran 1950) and Geary's *C* (Roy C. Geary 1954). Both measures helped to test whether a variable exhibits spatial dependence. They are simple, easily calculated, intuitive, and accurate indicators of spatial dependence. Both measures rely on the following formula, Moran's *I*: (Moran 1950; Sergio J. Rey and Brett D. Montouri 1999; Selin Özyurt and Stephane Dees 2018):

$$I = \frac{\sum_{j=1}^{n} \quad \sum_{i=1}^{n}(v_i-\bar{v})(v_j-\bar{v})w_{i,j}}{(y_i-\bar{y})^2}\frac{n}{W}, \tag{6}$$

(Geary 1954; Agata Sielska and Aleksandra Palowska 2016):

$$\text{Geary's } C = \frac{\sum_{j=1}^{n} \quad \sum_{i=1}^{n}(v_i-v_j)^2 w_{i,j}}{\sum_{i=1}^{n}(v_i-\bar{v})^2}\frac{n-1}{2W"}, \tag{7}$$

where *v* is the variable of interest in both measures, *I* and *j* are the two different regions, $w_{i,j}$ represents the spatial weights between two spatial units, *W* is the aggregate weights, *n* shows the number of observations. Positive and significant values of Moran's *I* or Geary's *C* point to a positive spatial correlation.

Two spatial weight matrix types were used in these tests. The first one was a raw standardized inverse distance matrix. In this type, the cells of the matrix take the value $1/d_{i,j}$, where $d_{i,j}$ represent the distance between regions *i* and *j* in kilometers. The greatest weight is given to the closest neighboring regions, and the least weight is given to the most distant regions.

The second type of matrix is the radial distance contiguity matrix. In this form, if two regions are closer than 400 km to each other, they are accepted as neighbors, and in that case, the matrix cells take a value of 1, or otherwise 0, such that

$$\begin{Bmatrix} 1 \text{ if } & d_{i,j} < 400 \text{ km} \\ 0 \text{ if } & d_{i,j} > 400 \text{ km} \end{Bmatrix}. \tag{8}$$

Both matrices are raw standardized, such that the sum of values in a raw is equal to 1. The distance data between the centers of regions are provided by the General

Directorate of Highways of Turkey (2018)[3]. The center of regions is determined as the center of the most populated city in the region.

The test results are shown in Table 4 which are performed for each year and the two variables separately. As a result, the output gap variable ($y - y^*$) is found to have a positive and spatial autocorrelation in most of the years and regardless of the type of spatial weight matrix. This result appears to be plausible, as the economic growth in a region (i.e., the positive shock to the output gap) may spill over to neighboring regions easily through trade, finance, and commuting linkages (Armstrong and Taylor 2000; LeSage 2008) Similarly, neighboring regions tend to have similar reactions to common and sector-specific shocks, as their industrial structure is often similar (Paul Krugman 1991; Şebnem Kalemli-Özcan, Bent Sorensen, and Oved Yosha 2001). Unlike the first variable, the unemployment variable ($u - u^*$) exhibits a spatial dependence, except for 2007. These results are consistent across Moran's *I* and Geary's *C*. Thus, spatiality is an important factor in this study and cannot be ignored.

However, the spatial linkages are not uniform throughout the country; rather, a certain spatial heterogeneity might be present. To deeply investigate this issue and illustrate such spatial heterogeneity, we apply a local Moran's *I* analysis for the most recent available year (2018).

A LISA analysis is a useful tool that helps in exploring the spatial groupings and heterogeneity of regions concerning the similarity of values in the variable of interest. LISA relies on the following formula (Anselin 1995; Rey and Montouri 1999):

$$\frac{(v_i-\bar{v})}{\sum_{i=1}^{n}(v_i-\bar{v})^2}\sum_{j=1}^{n}(v_j-\bar{v})\,w_{i,j}. \tag{9}$$

**Table 4** Moran's I and Geary's C Test Results

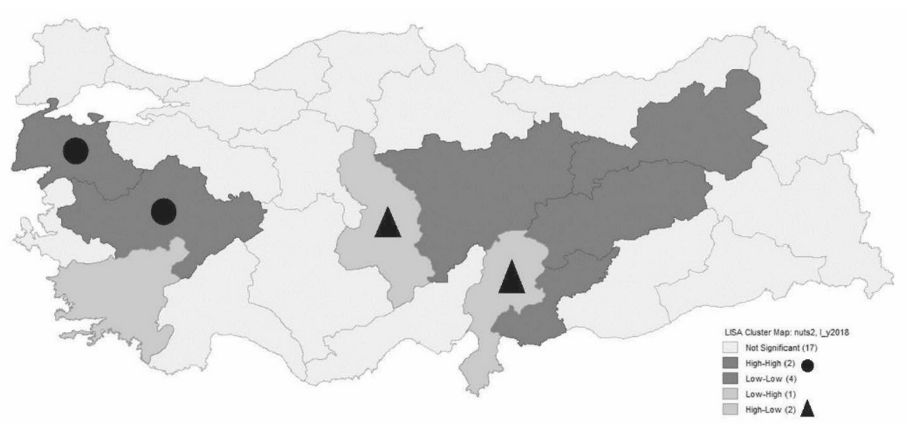
| Years | Moran I | | | | Geary C | | | |
|---|---|---|---|---|---|---|---|---|
| | Inverse distance | | Radial distance | | Inverse distance | | Radial distance | |
| | *u-u** | *y-y** | *u-u** | *y-y** | *u-u** | *y-y** | *u-u** | *y-y** |
| 2004 | -0,065 | -0,042 | -0,101 | 0,056 | 0,989 | 0,973 | 0,982 | 0,823* |
| 2005 | -0,049 | 0,052** | 0,069 | 0,259** | 0,998 | 0,900** | 0,937 | 0,670*** |
| 2006 | -0,077 | -0,035 | -0,159 | -0,015 | 0,979 | 0,983 | 1,073 | 0,964 |
| 2007 | 0,036** | -0,002 | 0,133* | 0,146* | 0,896** | 0,978 | 0,733** | 0,866 |
| 2008 | -0,031 | 0,184*** | -0,038 | 0,494*** | 0,975 | 0,765*** | 0,940 | 0,473*** |
| 2009 | -0,016 | -0,028 | 0,045 | 0,022 | 0,966 | 1,003 | 0,931 | 0,974 |
| 2010 | -0,040 | 0,077*** | -0,125 | 0,162* | 0,942 | 0,875*** | 0,983 | 0,798* |
| 2011 | -0,043 | -0,004 | -0,002 | 0,107 | 0,974 | 0,962 | 0,981 | 0,810* |
| 2012 | -0,118 | 0,107*** | -0,359 | 0,527*** | 1,042 | 0,809*** | 1,423 | 0,448*** |
| 2013 | -0,040 | -0,055 | -0,095 | -0,025 | 1,008 | 0,989 | 1,189 | 1,010 |
| 2014 | -0,017 | 0,084*** | -0,065 | 0,227** | 0,929* | 0,848*** | 1,067 | 0,720** |
| 2015 | -0,075 | 0,033** | -0,104 | 0,207** | 0,991 | 0,899** | 1,078 | 0,681** |
| 2016 | -0,083 | 0,093*** | -0,265 | 0,217** | 1,008 | 0,849*** | 1,212 | 0,702** |
| 2017 | -0,012 | -0,058 | -0,002 | -0,092 | 0,951 | 0,982 | 1,049 | 0,949 |
| 2018 | -0,062 | 0,138** | -0,211 | 0,292*** | 0,940 | 0,826*** | 1,181 | 0,640*** |

**Source:** Own calculations.

[3] **General Directorate of Highways.** 2018. www.kgm.gov.tr (accessed December 05, 2018).

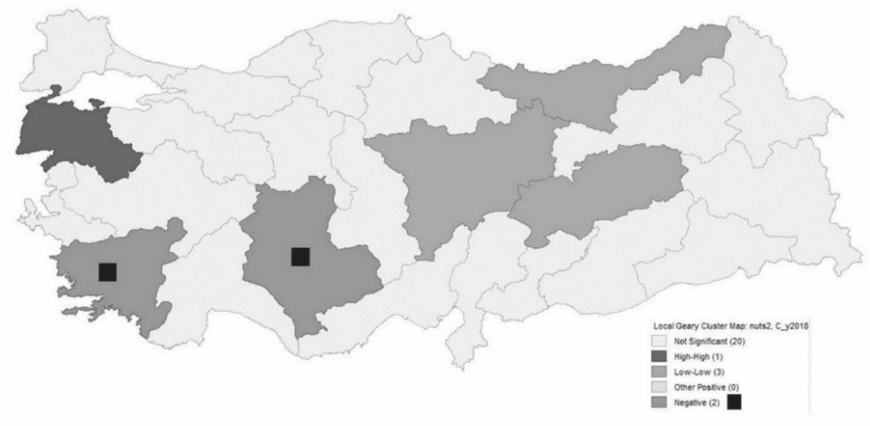
The results are presented in five categories: (i) high-high (high output gap values clustered by the neighbors that have high values in this variable); (ii) high-low; (iii) low-high; (iv) low-low; and (v) insignificant spatial clustering groups.

We present the results in Figure 2 (Anselin 1995)[4]. At a glance, it is observed that there is substantial spatial heterogeneity in regional output gaps ($y - y^*$), such that two Western regions (TR33 and TR22) generate a high-high cluster, in which both regions have high values of output. This appears to be reasonable, as both regions specialize in industry and trade, and growth spillover is probable among these regions *via* input-output linkages. In contrast, several regions in Mid-Eastern Anatolia (namely, TRC1, TR72, TRB1, and TRA1) create a low-low cluster. These regions are characterized by agricultural activities with relatively lower income, lower industrialization, and a more closed economy. It is plausible that these regions have a lower output gap (as they were negatively affected by the downturn in 2018) surrounded by neighbors with low output. Moreover, there is one small high-low cluster in Middle Anatolia (TR63-TR71) and a low-high cluster in Southern Aegean (TR32). The remaining regions have insignificant local spatial correlations. Regarding the results for the unemployment variable, less local spatiality is observed. A high-high cluster is generated by Northeastern regions (TRA1, TRA2, and TRB1), which are characterized by agriculture and non-dynamic sectors. Hence, it is natural that these backward regions have an unemployment rate above their natural rate. Finally, the TRC3 region forms a single-region low-high cluster.



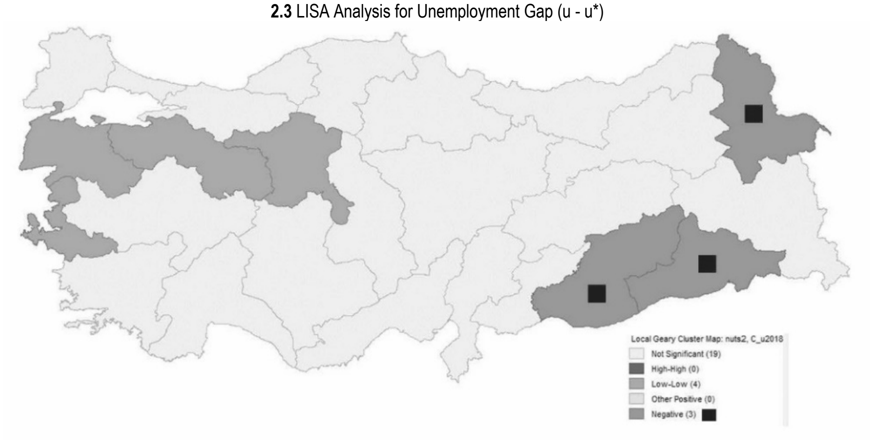

**2.1** LISA Analysis for Output Gap (y - y*)

[4] For technical details of LISA, see Anselin (1995).




**2.2** Local Geary Analysis for Output Gap (y - y*)


**2.3** LISA Analysis for Unemployment Gap (u - u*)




**2.4** Local Geary Analysis for Unemployment Gap (u - u*)

**Notes:** Weight matrix is rook type continuity and symmetric.

**Source:** Own calculation.

**Figure 2** LISA and Local Geary's C Analysis Results

To complement these results with an alternative method, local Geary's *C* was calculated (see Geary 1954 and Anselin 1995, for details). The results often appear to be consistent with local Moran's *I* analysis explained previously. Hence, spatial dependence and heterogeneity are firmly evident in our study. Therefore, it is essential to incorporate spatial autocorrelation and its heterogeneity in Okun's Law estimation.

## 2.4 Okun's Law Estimation

To estimate Okun's Law, the most general regression form is presented in Equation (2).

The model selection of panel and spatial regression models require formal selection tests. The three most well-known types of spatial models are presented as follows (James Durbin 1960; Anselin 1980, 1988; Anselin and Rosina Moreno 2003; Badi H. Baltagi, Seuch H. Song, and Won Koh 2003; Paul J. Elhorst 2003, 2009; Baltagi et al. 2007; Anselin, Julie Le Gallo, and Hubert Jayet 2008; Baltagi, Qu Feng, and Chihwa Kao 2012; Giovanni Millo and Gianfranco Piras 2012)[5]:

First, the spatial Durbin model:

$$(u-u^*)_{i,t} = \beta_0 + \beta_1 [(y-y^*)\times 100]_{i,t} + \rho W(u-u^*)_{i,t} + \\ + \partial W[(y-y^*)\times 100]_{i,t} + e_{i,t}. \tag{10}$$

Second, the spatial autoregressive model:

$$(u-u^*)_{i,t} = \beta_0 + \beta_1 [(y-y^*)\times 100]_{i,t} + \rho W(u-u^*)_{i,t} + u_{i,t}. \tag{11}$$

Third, the spatial error model:

$$(u-u^*)_{i,t} = \beta_0 + \beta_1 [(y-y^*)\times 100]_{i,t} + \exists_{i,t}, \qquad \exists_{i,t} = \lambda W \ \exists_{j,t}, \tag{12}$$

where $i$ = regions, 1…, 26, and $t$ = years, 2004, …, 2018. Error terms ($e,u,\exists$) represent independently, identically, and normally distributed error terms. Meanwhile, $W$ represents the spatial weight matrix, and $\rho$ captures the spatial spillovers among the unemployment gaps of regions.

To select the proper model, an essential technical analysis considers the possibility of spatial autocorrelation. We apply four different types of spatial autocorrelation tests and understand, in this way, the severity of the possible bias.

Spatial autocorrelation tests have two forms. The first assumes the possible spatial autocorrelation in the dependent variable. Meanwhile, the second instead assumes that the spatial component occurs in the error terms of the regression (Anselin et al. 1996; Anselin and Arribas-Bel 2013; Elhorst 2014).

Regarding the results, robust Lagrange multiplier lag tests indicate strong spatial autocorrelation in panel regression (Table 5). It is consistently evident regardless of the type of spatial weight matrix.

As a result, spatial autocorrelation is found to be statistically evident in both independent variables and error terms. Therefore, spatial autocorrelation must be incorporated in our regression analyses.

[5] In empirical analyses, R software packages SPLM (Millo and Piras 2012), SPDEP (Roger Bivand 2019), SPWGR (Bivand et al. 2020), software programs Geoda, Eviews 4, Eviews 10 and ARCGIS have been used.

Model selection is, however, a more complex task. It requires both intuitive and statistical approaches (Elhorst 2009).

To begin with an intuitive approach, dependent variable ($u - u^*$) can be spatially correlated, as variables affecting the labor market (such as migration, labor supply, and labor demand) can be geographically clustered. Any increase in these variables can easily spill over to the neighbors that can impact unemployment. For the spatial dependence in error terms, shocks to unemployment can evolve in a spatially cumulative manner. These shocks can be triggered by economic/demographic externalities, such as an unanticipated increase in migration, decrease in labor demand, or increase in labor supply. Regarding the spatial spillover in the independent variable (output gap), a jump in economic growth/downturn can easily spill over to the neighboring regions through trade, finance, and commuting flows and thereby affect the neighbor's unemployment rate (Armstrong and Taylor 2000; LeSage 2008). Spatial dependence in unemployment and GDP are empirically analyzed and found to be significantly evident in various studies on Turkey (Gezici and Hewings 2007; Filiztekin 2009).

**Table 5** Panel Spatial Autocorrelation Tests

| Test type | Spatial matrix type | |
|---|---|---|
| | Inverse distance | Radial distance |
| Spatial error dependence-LM test | 3,05* | 0,19 |
| Spatial lag dependence-LM test | 13,17*** | 1,92 |
| Spatial error dependence sub-spatial lag-locally robust LM test | 7,69*** | 9,13*** |
| Spatial lag dependence sub-spatial error-locally robust LM test | 17,81*** | 10,86*** |

**Source:** Own calculations.

Second, following a statistical approach for model selection, the LM specification tests in Table 5 indicate the necessity of spatial dependence component in the error terms and the dependent variable, as test statistics are significant. Hence, all these mechanisms should be analyzed in empirical models.

The most general forms of spatial regression models must consequently be employed. The most conventional form of spatial regressions is preferred by applying all three types – SDM (Spatial Durbin Model), SAR (Spatial Autoregressive Model), and SEM (Spatial Error Model) – and to cross-validate our results.

A final technical specification is the selection of the type of panel data specification. Region-specific or time-fixed effects might be present in variables (Baltagi, Song, and Koh 2003; Baltagi et al. 2007; Baltagi, Feng, and Kao 2012). Region-specific time-invariant effects might be driven by sectoral structures specific to the regions, geographical characteristics unique to regions, region-specific economic shocks (i.e., in prices or productivity, among others), or any other economic/social fixed factors specific to regions. In a similar manner, time-fixed effects may be present in the data set. The global economic crisis in 2008 serves as a good example of such an effect. Moreover, these regional and time effects can be present in the form of random movements in the data set.

For these reasons, it is necessary to apply a test to distinguish between fixed or random effects estimators. The Hausman test (Jerry A. Hausman 1978) is commonly used in the literature. Moreover, its spatial form was developed by Jan Mutl and Michael Pfaffermayr (2011). It examines the statistical differences across the estimated coefficients in fixed- and random-effects models by using a $\chi^2$ statistic and distribution.

Ho: The two models have identical coefficient estimations: consistency in both models.
Ha: The two models have different coefficient estimations: one model is inconsistent.
If the null hypothesis is correct, it can be used one of the either models because estimators in both models are consistent. If, however, the alternative hypothesis is correct, one should use the fixed-effects model because at least one model is inconsistent.

**Table 6** Hausman Panel Data Regression Specification Test

| Weight matrix type | Individual / twoway effects | Chi-square |
|---|---|---|
| Inverse distance | Individual | 0.0000000268 |
| Binary contiquity | Individual | 0.0000029600 |
| Inverse distance | Twoways | 0.0000000987 |
| Binary contiquity | Twoways | 0.0000002790 |

**Notes:** Two ways effects were maintained by adding time dummies, i.e. from 2004, ..., 2017. In spatial models, Manski model (Charles F. Manski 1993) (spatiality in both dependent variable, error terms and independent variables are allowed).

**Source:** Own calculations.

The test result is provided in Table 6. The Hausman $\chi^2$ statistic is insignificant in all cases, regardless of the type of spatial weight matrix and whether individual/two-way effects are allowed in the panel setting. Hence, both random- and fixed-effects models are appropriate.

We estimate the spatial panel models in several forms and present the results in Table 7. First, we adopt an SAR model (as in Equation (11) and Table 7a). In the first column, results regarding the entire period are presented. Initially, a pooling model that includes neither spatial nor fixed/random effects is performed. Afterward, a simple SAR model that includes no fixed/random effects is performed. Following this, in the second column, pooled-, fixed-, and random-effects SAR models are performed for upswing and downswing years, separately. The years in which the output is above (below) its trend are referred to as the upswing (downswing) years. The same procedure is applied when the results of SEM (as in Equation (12) and Table 7b) and SDM (as in Equation (10) and Table 7c) estimation are presented. Both the inverse distance and radial distance type of the spatial weights are used.

Several crucial results appear to emerge from the estimations. First, regarding the results from SAR (Table 7a), it has been demonstrated quite clearly that spatial dependence and cyclical asymmetry are important. When the aggregate period is analyzed, the estimated Okun's coefficient is between 0.15 and 0.21, whereas it is found, during upswing years, to be approximately 0.10 to 0.13 and, during downswing years, to be approximately 0.24 to 0.18. Hence, the Okun's coefficient is found to be twice as high during downswing years compared with upswing years. This result is consistent across different regression settings, such as pooled-/random-/fixed-effects models or across the different spatial weights adopted. Moreover, the estimated parameters are always significant at the 1% level. Thus, during upswing years, GDP and unemployment have a weaker relationship, whereas during downswing years, the association is quite strong. In other words, this means that ignoring the spatial proximity and cyclical asymmetry leads to the overestimation of Okun's coefficient during upswing and underestimation during downswing periods.

As another important result, the spatial spillover component (rho) is positive and often significant. The result sounds plausible, as the economic growth and unemployment are likely to spill over to the neighboring regions through trade, financial commuting, and migration linkages. This, in turn, causes the direct association between the output and unemployment to be stronger in the case when negative economic shocks are present.

Second, the estimation results of the SEM model do not change the story. In Table 7b, it is presented clearly that cyclical asymmetry is again important. When the aggregate period is analyzed, the estimated Okun's coefficient is approximately 0.19 to 0.22. While it is found to be approximately 0.12 to 0.13 during upswing years, it is found to be far higher during downswing years, at approximately 0.24 to 0.26. Hence, the Okun's coefficient is again found to be twice as high during downswing years compared with upswing years. This result is consistent across different regression settings, such as across pooled-/random-/fixed-effects models or the different spatial weights adopted. The estimated Okun's coefficients are significant at the 1% level.

Finally, the results of the SDM model are presented in Table 7c. During the entire period, the Okun's coefficient is estimated as approximately 0.22 when no spatial components are added and approximately 0.05 to 0.09 when spatial components are included. During upswing years, Okun's Law is approximately 0.04 to 0.06, and during downswing years, it is approximately 0.09 to 0.16. Interestingly, the spatial lag of the independent variable ($Wy$) has significant and negative coefficient. Thus, an increase in the output of a region lowers the unemployment rate of its neighbors. This appears to be theoretically feasible, as the growth process creates a certain multiplier effect in the form of positive externality and spills over to the other regions and increases their employment (Armstrong and Taylor 2000; LeSage 2008).

**Table 7** Spatial Panel Regression Results

**(7.a) SAR model**

| **Spatial weight matrix: radial distance** | **Whole period** | | **Upswing periods** | | | **Downswing periods** | | |
|---|---|---|---|---|---|---|---|---|
| **Panel regression type:<br>Spatial regression type:** | **Pooling<br>No spatial component** | **Pooling<br>SAR** | **Pooling<br>SAR** | **Random effect<br>SAR** | **Within fixed effect<br>SAR** | **Pooling<br>SAR** | **Random effect<br>SAR** | **Within fixed effect<br>SAR** |
| Constant | 0,000 | 0,000 | -0,157* | -0,157* | | 0,084 | 0,084 | |
| Y | -0,219*** | -0,202*** | -0,128*** | -0,128*** | -0,129*** | -0,244*** | -0,244*** | -0,251*** |
| Rho | | 0,076 | 0,030 | 0,030 | 0,034 | 0,051 | 0,051*** | 0,057 |
| **Spatial weight matrix: inverse distance** | **Whole periods** | | **Upswing periods** | | | **Downswing periods** | | |
| **Panel regression type:<br>Spatial regression type:** | **Pooling<br>No spatial component** | **Pooling<br>SAR** | **Pooling<br>SAR** | **Random effect<br>SAR** | **Within fixed effect<br>SAR** | **Pooling<br>SAR** | **Random effect<br>SAR** | **Within fixed effect<br>SAR** |
| Constant | 0,000 | 0,000 | -0,128 | -0,128 | | 0,061 | 0,061 | |
| Y | -0,219*** | -0,151*** | -0,109*** | -0,109*** | -0,109*** | -0,180*** | -0,180*** | -0,181*** |
| Rho | | 0,321*** | 0,198 | 0,199*** | 0,213 | 0,304* | 0,304* | 0,327** |

**(7.b) SEM model**

| Spatial weight matrix: radial distance | Whole period | | Upswing periods | | | Downswing periods | | |
|---|---|---|---|---|---|---|---|---|
| **Panel regression type :<br>Spatial regression type:** | **Pooling<br>No spatial component** | **Pooling<br>SEM** | **Pooling<br>SEM** | **Random effect<br>SEM** | **Within fixed effect<br>SEM** | **Pooling<br>SEM** | **Random effect<br>SEM** | **Within fixed effect<br>SEM** |
| Constant | 0,000 | 0,000 | -0,163** | -0,163** | | 0,089 | 0,089 | |
| Y | -0,219*** | -0,217*** | -0,131*** | -0,131*** | -0,133*** | -0,258*** | -0,258*** | |
| Lambda | | 0,027 | 0,009 | 0,009 | 0,015 | -0,012 | -0,012 | 0,018 |
| **Spatial weight matrix: Inverse distance** | **Whole periods** | | **Upswing periods** | | | **Downswing periods** | | |
| **Panel regression type:<br>Spatial regression type:** | **Pooling<br>No spatial component** | **Pooling<br>SEM** | **Pooling<br>SEM** | **Random effect<br>SEM** | **Within fixed effect<br>SEM** | **Pooling<br>SEM** | **Random effect<br>SEM** | **Within fixed effect<br>SEM** |
| Constant | 0,000 | 0,000 | -0,175* | -0,175* | | 0,122 | 0,122 | |
| Y | -0,219*** | -0,193*** | -0,119*** | -0,119*** | -0,119*** | -0,239*** | -0,239*** | -0,245*** |
| Lambda | | 0,234* | 0,142 | 0,143 | 0,161 | 0,176 | 0,176 | 0,244 |

**(7.c) SDM model**

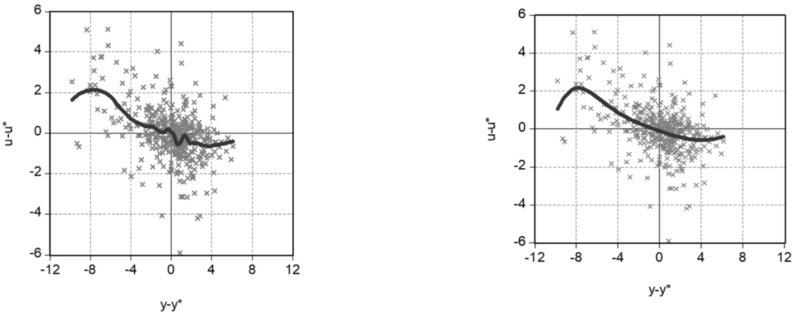
| Spatial weight matrix: radial distance | Whole period | | Upswing periods | | | Downswing periods | | |
|---|---|---|---|---|---|---|---|---|
| **Panel regression type<br>Spatial regression type** | **Pooling<br>No spatial component** | **Pooling<br>SDM** | **Pooling<br>SDM** | **Random effect<br>SDM** | **Within fixed effect<br>SDM** | **Pooling<br>SDM** | **Random effect<br>SDM** | **Within fixed effect<br>SDM** |
| Constant | 0,000 | 0,000 | -0,128 | -0,128 | | 0,045 | 0,045 | |
| Y | -0,219*** | -0,091** | -0,061 | -0,061 | -0,064 | -0,124 | -0,124 | -0,158* |
| Wy | | -0,158*** | -0,110* | -0,110* | -0,104* | -0,167** | -0,167** | -0,122 |
| Rho | | 0,011 | -0,004 | -0,004 | 0,002 | -0,026 | -0,026 | 0,007 |
| **Spatial weight matrix: inverse distance** | **Whole periods** | | **Upswing periods** | | | **Downswing periods** | | |
| **Panel regression type<br>Spatial regression type** | **Pooling<br>No spatial component** | **Pooling<br>SDM** | **Pooling<br>SDM** | **Random effect<br>SDM** | **Within fixed effect<br>SDM** | **Pooling<br>SDM** | **Random effect<br>SDM** | **Within fixed effect<br>SDM** |
| Constant | 0,000 | 0,000 | -0,093 | -0,093 | | 0,016 | 0,016 | |
| Y | -0,219*** | -0,053 | -0,038 | -0,038 | -0,039 | -0,080 | -0,080 | -0,093 |
| Wy | | -0,179*** | -0,144** | -0,144** | -0,139* | -0,188** | -0,188** | -0,149 |
| Rho | | 0,144 | 0,084 | 0,085 | 0,104 | 0,103 | 0,103 | 0,184 |

**Source:** Own calculations.

A last step of empirical analysis is needed to check the validity of asymmetric impacts by using another methodology. Therefore, for the sake of robustness, we refer to the following nonparametric regression specification:

$$(u-u^*)_{i,t} = f(y-y^*)_{i,t}. \quad (13)$$

We apply the function in Equation (13) by first using a local polynomial kernel regression (of order = 2) under the assumption of normally distributed variables and, second, a nearest neighbor fit local polynomial (of order 2) regression (Mervyn Stone 1974; Jacqueline K. Benedetti 1977; John W. Tukey 1977; William S. Cleveland 1979; Cleveland, Susan J. Devlin, and Eric Grosse 1988; Wolfgang Hardle 1990; Cleveland and Grosse 1991; Naomi S. Altman 1992). The results are presented in Figure 3.




**3.a** LOESS Nearest Neighbor Fit, Polynomial Order = 2

**3.b** Local Polynomial (Order = 2), Normal Distribution, Kernel Regression

**Figure 3** Non-Parametric Regression Analysis

In both graphs, we clearly observe the asymmetric effect of the GDP cycle on unemployment rates. Hence, during upswing years, an increase in GDP (above its potential) does not lead to a remarkable decline in unemployment, whereas during downswing years, unemployment increases (decreases) sharply in response to a decline (increase) in the GDP gap. Thus, the results found in the spatial panel regression analysis have once more been confirmed.

## 2.5 Cross-Regional Variation of Okun's Law: Geographically Weighted Regression

The last step in our analysis is to explore the regional differences in Okun's coefficient, which will provide useful insights into the validity and geography of Okun's Law.

Before proceeding with the analysis, it is worthwhile to briefly discuss the general characteristics of the regions (as presented in the map in Figure 5). First, the Marmara region is currently the most populated region and is located in the Northwest part of the country. It consists of a primarily urban population and has quite large metropolitan regions that specialize in the service sector, trade, and finance sectors (i.e., TR10 Istanbul) and regions that form the industrial belt of the country (TR41, TR42, TR21, and TR22).

Second, the Ege region is located on the Aegean Sea coast. This region is characterized by large trade-based port cities (i.e., TR31.İzmir) on the coast and industrial cities in its hinterland (TR33 Manisa). Third, the Middle Anatolian (İç Anadolu) region includes Ankara (TR51 capital city that has an intensive public sector) in the core and agriculture-based cities surrounding it (TR52, TR71, and TR72).

Fourth, the Akdeniz region is located on the Mediterranean Sea coast and is particularly characterized by regions that specialize in the tourism and service sectors (TR32, TR61, TR62, and TR63). Fifth, the Karadeniz (Black Sea) region is located on the northern Black Sea coast and represents a typical rural and agriculture fishery zone (TR90, TR81, TR82, and T83).

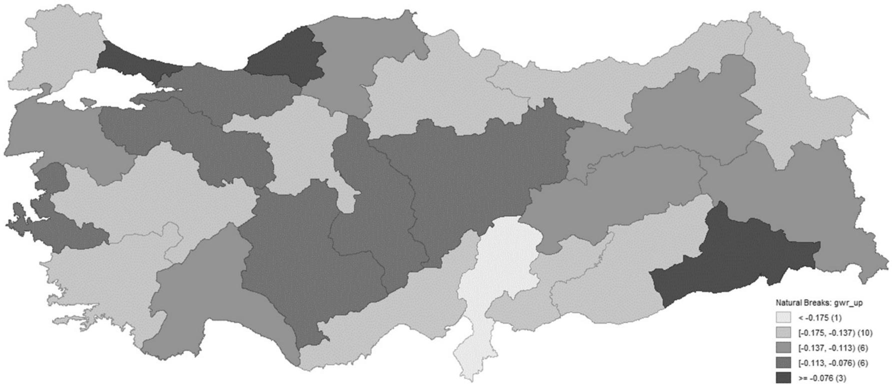
Sixth, the Eastern Anatolian (Doğu Anadolu) region is located in the eastern part of the country along the Armenian and Iran border (TRA1, TRA2, TRB1, and TRB2). It includes primarily rural areas and agriculture/horticulture-based economic activities. Seventh, the Southeast Anatolian (Güneydoğu Anadolu) region is located along the Iran, Iraq, and Syrian border. The main characteristic is the trade- and agriculture-based economic activities (TRC1, TRC2, and TRC3).

We adopt a GWR in panel regression form (equation 14), which is quite a useful tool for exploring region-specific Okun's Law (Stewart A. Fotheringham, Chris Brundson, and Martin Charlton 2002; Antonio Paez, Steven Farber, and David Wheeler 2011). It is important that GWR allows for spatial nonstationarity. In other words, it is possible to allow cross-regional variation and estimate the coefficients separately for each region, thanks to the help of this model.

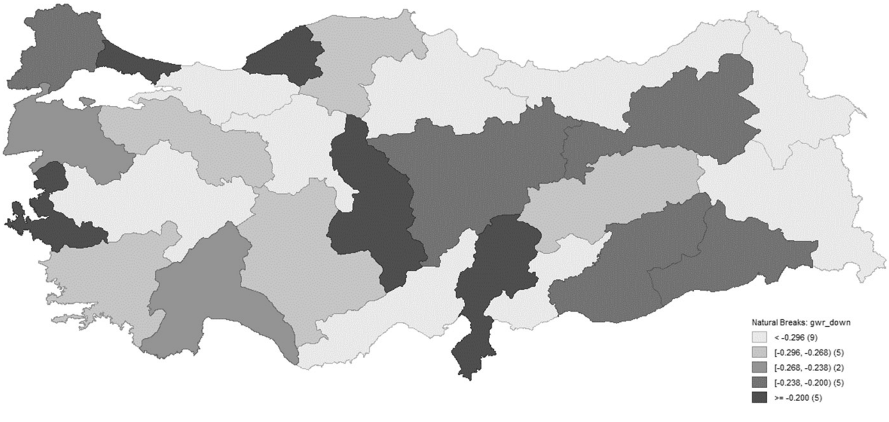
$$(u-u^*)_{i,t} = \beta_0 + \beta_{\mathrm{i}}\,(y-y^*)_{i,t} + e_{i,t}\,, \tag{14}$$

where $i$ denotes the 26 NUTS-2 regions. We estimate this GWR model separately for upswing and downswing years. The estimated coefficients are illustrated on maps, which are presented in Figures 4a (upswing years) and 4b (downswing years).

As a result, we observe that Okun's coefficient ($\beta_i$) varies quite substantially across regions. It ranges from 0.07 to 0.17 during upswing years and 0.20 to 0.29 during downswing years.




**4.a** Upswing Years

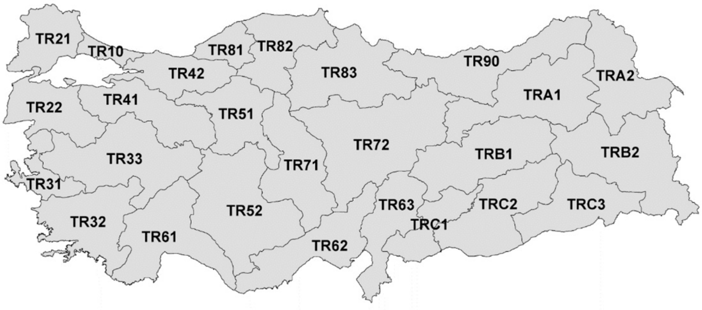



**4.b** Downswing Years

**Source:** Own calculation.

**Figure 4** Panel GWR Local Coefficients

Beginning with the results for upswing years, the size of the Okun's coefficient is high along the South Aegean/Mediterranean coast and Southern regions (TR32, TR61, TR62, TR63, TRC1, and TRC2) and the Black Sea coast and Northeastern regions (TR90, TR83, and TRA2). While the latter is firmly an agriculture/horticulture zone, the former is a services (i.e., tourism) and trade zone. These regions benefit the economic growth during upswing years and lower the unemployment rate. This is primarily driven by the nature of tourism and trade sectors, which can expand easily during a stable and high-growth economic climate.




**Source:** Own calculation.

**Figure 5** Geographical NUTS-2 Level Regions in Turkey

The high coefficient in the Black Sea coast can be interpreted differently. During the boom times, labor mobility becomes faster, and many people migrate from these less developed places to Western urban areas. Particularly young and unqualified workers tend to migrate. Hence, in these backward regions, unemployment appears to be low, as they lose their labor force.

In contrast, industrial zones (TR41, TR42, TR81, and TR72) and urban giants (Istanbul TR10, İzmir TR31, TR52, and TRC3) are among the regions that cannot reduce unemployment during high economic growth times. It follows that massive in-migration to these large cities greatly increases the labor supply, and therefore, the economic growth cannot lower unemployment in these regions because of the massive increase in labor supply.

During the downswing years, the picture often remains the same, with some differences. Again, the size of the Okun's coefficient is high along the South Aegean/Mediterranean coast (TR32, TR62, and TRC1) and the Black Sea coast (TR83 and TR90), Eastern Anatolia (TRA1 and TRA2), and some of the industrial zones (TR41, TR42, and TR33). The coefficient might be high in tourism areas because the nature of the services sector (mostly tourism) is easily affected by economic downturns. As it is not an urgent good and the demand for tourism is easily cut in the case of negative shocks, employment tends to decrease during these periods. Moreover, because the workers are contracted for only the short-term and in a temporary fashion, they are easily fired during economic downturns. Similarly, industrial zones are so sensitive to economic downturns, as investments in industry depend primarily on credit and monetary circumstances. The demand for durable goods (cars, machines, and so on) is quite volatile, as these goods are not urgent and can easily be postponed. Agricultural zones might experience similar adverse effects; during downturns, agricultural producers suffer energy prices and other costs and therefore reduce the number of employees.

Controversially, the coefficient size is low in large ports, their hinterland, and trade zones (TR10, TR31, TR63, and TR21). Thus, during downswing years, unemployment does not increase as rapidly in these regions. Trade might play a stabilizing role in this case, as the companies in these areas operate for both domestic and international markets, which offset each other in case one experiences a negative shock.

To compare our results from the GWR analysis with those found in the literature, we may refer to various existing studies. Mustafa Ege Yazgan and Hakan Yılmazkuday (2009) pursue a GWR analysis and estimate Okun's coefficient for US states during the period from 1978 to 2002. In their analyses, they found that estimated Okun's coefficients form geographical clusters. Over time, these coefficients tend to become similar and more homogenous across states. Our results indicate greater heterogeneity across regions. Another study was implemented by Elhorst and Anette İlly (2009) on European regions. GWR estimation of Okun's coefficient indicates a spatially varying pattern. In particular, South European regions (in Spain and Italy) exhibit higher levels. Similar to the study by Yazgan and Yılmazkuday (2009), the distribution of Okun's coefficient is spatially correlated. Luca Salvati (2015) estimated the local Okun's coefficient for 686 local Italian labor market areas during the period from 2004 to 2005; the estimated coefficients indicate large spatial variation, where higher coefficients are observed in rural areas close to metropolitan zones. Finally, Karolina Lewandowska-Gwarda (2018) analyzed 380 local Polish districts and their determinants of unemployment by using GWR and found quite diverse determinants across districts. Our study has diverse findings compared with the results of these studies. We found that while Okun's coefficient is rather uniform across regions during downturns, it is quite heterogeneous during upswing years. This asymmetry has not been considered and explored in the studies above.

To summarize the empirical results obtained thus far, Okun's coefficient is quite cyclically asymmetric in nature. Whereas it weakly holds during upswing years, it holds strongly during downswing years, as the size of Okun's coefficient is quite large. Spatial clusters and dependence are evident in our study. Unemployment and the GDP gap serve as evidence of spatial heterogeneity. Finally, as a result of the GWR analysis, it has been demonstrated that Okun's coefficient varies significantly across regions and business cycle phases. The estimated coefficients are quite heterogeneous, which necessitates region-specific solutions to the unemployment problem.

## 3. Policy Discussion

The results obtained bear important economic and political implications. Before explaining the specific policy suggestions, it is informative to provide an overview and comparison of the national macroeconomic and regional policies in Turkey.

In recent years, the main macroeconomic policy relies on targeting high economic growth triggered by massive domestic and foreign investments, international trade, and domestic demand. A large amount of cheap imports (energy and intermediate goods) helps to maintain the necessary inputs and control inflation. In terms of economic structure and sectoral specialization, whereas the share of the service, construction, and industry sectors tends to increase, the share of the agriculture sector has been declining quickly.

In terms of regional development policies, new regionalism approach, instead of traditional regionalism, has been adopted. Therefore, potentials and local knowledge of regions are attempted to be discovered and fulfilled by local actors (Stephen M. Wheeler 2002; Mehmet Samet Erdem 2019). Development agencies mediate this system by financing the development project offered by local actors (Wheeler 2002; Erdem 2019). In addition, sectoral specialization and land use patterns (i.e., tourism regions, industrial zones, and so on) have been shaped by both local and central actors.

However, it is suspicious that all these policies can provide a solution to the regional unemployment problem. The recent unemployment rate is still quite high, and some regions suffer much more than others. It is therefore important to adopt policies that increase job-creating economic growth. It is unclear whether national policies fulfill the necessities regarding regional employment creation; hence, region-specific policies are required.

Moreover, it is critical to assess whether regionally specialized sectors are the correct ones to create employment. The policies should generate concrete solutions to the migration of active labor from underdeveloped agricultural/rural areas to developed urban giants. Moreover, the policies should provide solutions to unemployment by educating the labor force in such a way as to add qualified and technical workers to the market. In this way, the mismatch and frictional problems of the labor market can be solved, thereby helping to reduce unemployment. Moreover, the flexibility of labor markets should be maintained to make them function properly.

The most important result arising from our analysis is that the unemployment problem is a more difficult and complex problem than initially understood. Regarding specific policy outcomes, during the downswing years, negative/slow output growth reduces the employment growth so sharply that it leads to high unemployment rates. Meanwhile, during the boom periods, the problem is unsolved as well because the linkage between output and unemployment is quite weak. In other words, during upswing years, economic growth can hardly generate employment.

It is thus understood that economic growth itself is not solely a solution to unemployment. Hence, special policies, such as subsidizing the job hiring processes, public employment programs, stimulation of labor-intensive industries, and export orientation, are needed. More structural solutions (reforms) are required, such that the deregulation of the labor market and reorganization of the market institutions toward a more flexible system and the stimulation of specializations in employment-creating sectors (i.e., manufacturing) are among the best possible policies.

Another set of policy suggestions concerns the regional heterogeneity of Okun's coefficient, which indicates the necessity of region-specific policies. Perhaps the most problematic places are the industrial regions (TR41, T42, TR21, TR81, and TR33), as their coefficient is relatively not large during booms but highly sizable during downswing years. In other words, they suffer recessions but cannot take advantage of booms in terms of employment creation. Regarding the policy implications, several suggestions can be made. First, these regions are unable to generate employment during high growth periods; therefore, employment-creating sectors should be encouraged. The technical labor force should be developed through formal and informal education. Moreover, one reason behind the increase in unemployment is the massive migration during boom years greatly increasing the labor supply in industrial regions. This pattern should be mitigated by promoting job and education facilities in backward regions. During downswing years, industrial areas have a sizable Okun's coefficient. To overcome the rapid increase in unemployment during these periods, fiscal aid and other assistance programs should be directed to these regions. Furthermore, structural reforms, such as promoting industrial diversity that can lower the cyclical sensitivity and the risk of sector-specific shocks, should be encouraged (Emil E. Malizia and Shanzi Ke 1993).

Similarly, various urban giants (TR10 Istanbul and TR31 İzmir) have low-sized coefficients during upswing years. One possible solution is to search for ways to slow down the massive migration during expansionary times to these regions. In this way, an increase in the labor supply can be mitigated, and thus, unemployment can be lowered.

For the Aegean/Mediterranean and Southern regions (Tourism Belt), a relatively sizable Okun's coefficient has been found during both upswing and downswing years, indicating that during downswing years, unemployment increases rapidly. Several policy suggestions can be made. The labor market should be restructured by increasing the number of technical and qualified workers. To do so, many technical schools that target to provide related training should be opened. Second, sectoral diversification should be promoted. These regions should not only rely on tourism and a few related sectors, but also trade and industry should be stimulated. In this way, the regions will become less sensitive to tourism shocks.

Another group of regions that has a highly sizable Okun's coefficient is the agriculture/horticulture-based areas clustered around the Blacksea and Northeastern parts of Turkey. During recessions, these sectors and employment should be stimulated via fiscal aid. It is important to modernize and make agriculture an economically feasible activity. In this way, these regions can overcome the massive out-migration of the productive labor force and maintain the level of employment during upswing and downswing years.

## 4. Conclusion

This article investigated the relevance of Okun's Law and sizable distortions that can occur in the estimation of Okun's coefficient when spatial dependence and cyclical asymmetric impacts are ignored in addition to the possible spatial heterogeneity in Okun's coefficient and related policy outcomes.

A panel of 26 Turkish NUTS-2 regions during the period from 2004-2018 was analyzed by using various methods which are respectively panel unit root and cointegration tests, global spatial dependence tests (Moran's *I* and Geary's *C*), local Moran's *I* and local Geary's *C* analysis, spatial LM tests, spatial panel fixed-effects and random-effects estimations, nonparametric panel regressions, and GWRs.

As a result, it is clearly revealed that failure to incorporate spatial proximity and asymmetric cycle impacts leads to the overestimation of Okun's coefficients during upswing years and underestimation during downswing years. Hence, severe cyclical asymmetry has been found in Okun's Law: During the downswing years of the national economy, unemployment increases quickly in response to a decline in the output gap. However, economic growth during upswing years can hardly generate employment.

Therefore, as an important policy implication, it is well understood that the reduction of unemployment is a more difficult task than initially understood, as economic growth itself does not provide a real solution during expansion periods. Moreover, the need exists for special policies, particularly to mitigate the destructive impact of recessions, such as employment subsidy programs, institutional reorganizations, reforms, and other heterodox policies targeted toward labor market modernization.

As another important conclusion, heterogeneous spatial patterns and dependence are crucial in our case. There is evidence of global positive spatial dependence and important local spatial heterogeneities in variables. Moreover, Okun's coefficient varies significantly across regions during upswing and downswing years. In detail, Southern coastal tourism areas and Northeastern agricultural regions appear to have a sizable coefficient during both upswing and downswing years. Furthermore, industrial regions have a low-sized coefficient during upswing and a high-sized coefficient during downswing years.

To summarize, cyclical asymmetries and spatial dependence should always be incorporated in Okun's Law studies. The business cycle phase and region-specific solutions should be formulated to overcome the unemployment problem in Turkey.

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