Regional Income Convergence in Turkey: An Empirical Analysis from an Endogenous Growth Perspective[*]

Hakki Kutay BOLKOL
Istanbul 29 Mayis University, Department of Economics, Istanbul[†]

Received: 28 April 2019; 29 July 2021.

Summary: This study analyzes convergence among regions of Turkey from an endogenous growth perspective. The results show that human capital, which is represented with R&D personnel, has a negative impact on economic growth in the regions based on its percentage in total employment. Moreover, we find that there is an estimated U-shaped relationship, which implies that if the percentage of R&D personnel in total employment increases after a certain level, the effect has a tendency of turning positive; the west region is especially closer to having a positive effect. However, regarding convergence, the relatively high-income west is closer to experiencing the positive effect of R&D personnel. Moreover, due to the relatively low percentage of R&D personnel in the east region, the economic growth of the east region is more negatively affected by R&D personnel. Therefore, using a strategy that is based on increasing the percentage of R&D personnel cannot help the east region to close the differences in income.

Keywords: Economic growth, Regional convergence, Human capital, Research and development, Turkey

JEL: O30, O47, O50, R11, R15

1. Introduction

The study of Robert M. Solow (1956) can be called a pioneer in the convergence literature. In his theory of neoclassical growth, the reason for convergence is the assumption of a decreasing return to scale to capital. In other words, relatively low income and capital stock regions obtain higher returns from an additional unit of capital, which leads to convergence. In his subsequent work, Solow (1957) discussed saving behavior using the utility maximization framework. He concluded that 80% of the US output per worker growth is due to technological progress. Neoclassical models, including that of Solow (1956), can be called exogenous technology growth models since they treat technology as an exogenous factor. Technology is included in total factor productivity (TFP); in other words, it is the Solow residual in neoclassical models. TFP is the unexplained part of economic growth that is not related to capital

[*] This paper was adopted from Hakki Kutay BOLKOL's PhD thesis at Marmara University submitted in April 26, 2019.

[†] E-mail: hkbolkol@29mayis.edu.tr

or labor. Technological advancement is accepted as an explanation for TFP. Thus, what is left after subtracting the proportion of capital and labor from output is TFP.

Endogenous growth models try to explain TFP by describing human capital as an engine of economic growth because according to endogenous technology growth models, human capital accumulation increases the productivity of labor and physical capital. However, human capital is quite different from physical capital in terms of the assumption of decreasing returns. Researchers who have worked on this issue have found that instead of decreasing returns, increasing returns is dominant in human capital. Therefore, this situation causes divergence rather than convergence. The aim of this study is to empirically investigate this issue in the regions of Turkey.

2. Literature Review

Paul M. Romer (1986) developed a model of increasing returns in which he endogenously determined how the level of knowledge, which is a product of research technology, leads to a stable equilibrium growth rate in an economy. Unlike Solow (1956), Romer (1986) proposed an alternative approach to long-run economic growth, where in a fully specified competitive equilibrium, per capita output can grow without bound, possibly at a rate that is monotonically increasing over time. Although this situation violates Pareto optimality, social optimum can be obtained by using the assumption of decreasing return to scale to research technology, which implies that doubling the inputs considered in a research will not double the amount of new knowledge produced. Thus, the assumption of increasing return to scale to human capital leads to divergence rather than convergence.

Including human capital introduces a new perspective into the field of economic growth. After Romer (1986), Robert E. Lucas (1988) also endogenized economic growth. The main idea presented in the study of Lucas (1988) is that people divide their time between work and training so that a trade-off between work and training emerges because, during training, people renounce their work income but enhance their future productivity and thus their future wages. This situation is related to postponing income today for better income tomorrow. The decision depends on the dynamics of the economy, and this makes the model endogenous.

The seminal works of Romer (1986) and Lucas (1988) paved the way for other seminal studies, such as those of Paul M. Romer (1990); Gene M. Grossman and Elhanan Helpman (1990, 1991, 1993, 1994); David T. Coe and Elhanan Helpman (1995); David T. Coe, Elhanan Helpman, and Alexander W. Hoffmaister (1997); Peter Howitt (1999); Philippe Aghion and Peter Howitt (1998); and Philippe Aghion, Ufuk Akcigit, and Peter Howitt (2013), which made several important contributions to the endogenous growth theory, such as by discussing it from the perspectives of international trade via diffusion of technology (Grossman and Helpman (1990, 1991, 1993, 1994), Coe and Helpman (1995), Coe et al. (1997)) and Schumpeterian (Aghion et al (2013)).

In the literature, there is a lack of empirical endogenous models that are constructed for regional analysis. Ron Martin and Peter Sunley (1998) argued that the endogenous growth theory provides significant conclusions in terms of regional policies; however, there are major limitations of applying the theory in a regional context. This is due to the difficulty in constructing a model with the assumption of increasing returns when there is no barrier to the movements of prices, wages, and capital within a county. However, the mobility of human capital is quite different from others. Lucas (1988) also mentioned that there is an interaction and externality feature of human capital even within a country, so its mobility is not easy as other factors. Therefore, simple econometric models that are constructed from an endogenous growth perspective and focus only on human capital can also provide valuable insight into regional economic growth. Hence, aside human capital, regional inequalities and development can also be controlled by using simple econometric techniques, such as constructing a dynamic model and using a lagged dependent variable that includes all other factors (as it will be done in this work).

Only a few empirical studies have analyzed this issue using basic econometric techniques. For instance, Yingqi Wei, Xiaming Liu, Haiyan Song, and Peter Romilly (2001) found that R&D expenditures (source of increasing the level of human capital) have a significant impact on economic growth in regions of China, which proves the validity of endogenous growth theories. Eckhardt Bode (2002) investigated the regions in Germany and found that human capital, which is denoted by R&D personnel, has a significant and positive effect on income growth. Hiro Izushi (2008) examined 31 European NUTS1 (NUTS is the abbreviation for nomenclature of territorial units for statistics; the abbreviation comes from the French version, which is nomenclature des unités territoriales statistiques) regions with several types of endogenous growth models adopted from Lucas (1988) and Romer (1990) and found that the Lucasian framework provides valuable insight into the technical progress of a regional economy. Wei-Hwa Pan and Xuan-Thang Ngo (2016) investigated the regional performance of 64 Vietnamese provinces from the perspective of the endogenous growth theory and found that the empirical results do not fully support the endogenous growth model. Therefore, they doubted the validity of the endogenous growth theory in the early stage of less developed countries.

As already mentioned, the regional endogenous literature lack empirical studies. However, in addition to direct regional growth analyses, several studies have also employed the endogenous growth theory to analyze regional competitiveness. Paul Plummer, Matthew Tonts, and Kristen Martinus (2014) employed the endogenous growth theory to analyze local competitiveness and regional development in Western Australia’s regional cities and found that local competitiveness plays a significant role in regional policies. Slobodan Cvetanovic, Milorad Filipovic, Miroljub Nikolic, and Dusko Belovic (2015) also discussed regional development issues using the endogenous growth theory and highlighted the importance of regional competitiveness in economic development.

As already mentioned, there is a lack of empirical study that investigates regional convergence from an endogenous growth perspective. However, there are several studies about regional convergence in Turkey. Since this work is an empirical study about Turkey, the next section includes studies that have empirically analyzed regional convergence in Turkey, whether they examined the subject from an endogenous growth perspective or not. In addition, in the next section, studies that have examined the relationship between human capital and economic growth in Turkey or have addressed endogenous growth models in their analysis are also included, although they do not include regional analysis.

2.1 Empirical Studies on Turkey

Alpay Filiztekin (1998) investigated the regional convergence issue in Turkey using provincial level data from 1975 to 1995. He used neoclassical beta convergence methodology and found that whereas there is conditional beta convergence, there is no absolute beta convergence.

Aysıt Tansel and Nil Demet Güngör (1999) also investigated the regional convergence issue using provincial level data from 1975 to 1995. The specialty of this study is how it tested whether convergence is conditional on human capital. They found that there is an absolute convergence for provinces in Turkey and adding human capital increases the convergence rate.

Fatma Doğruel and A. Suut Doğruel (2003) investigated the convergence issue from 1987 to 1999 using neoclassical beta convergence methodology. They also used several descriptive statistics, such as sigma convergence and coefficient of variation. They showed that although crises and natural disasters create convergence among provinces of Turkey, during general periods, the picture is closer to divergence.

Orhan Karaca (2004) used neoclassical beta convergence methodology in his study. The research period of his study is from 1975 to 2000. He also used other descriptive statistics, such as sigma convergence and the coefficient of variation in order to achieve valid results. The empirical results of this study show that there is divergence among provinces of Turkey.

Beta convergence, sigma convergence, and the coefficient of variation methodologies have also been used by Ferhan Gezici and Geoffrey JD Hewings (2004). The research period of their study is from 1980 to 1997. They found that there is no evidence for convergence among Turkish provinces.

Altan Aldan and Esma Gaygisiz (2006) also investigated the regional convergence issue with provincial level data from 1987 to 2001. Aside using neoclassical beta convergence methodology and provincial level data, this study also used spatial analysis techniques. According to the results of the study, although there is spatial spillover in the growth process of provinces, no evidence of convergence was found.

More recently, Burhan Can Karahasan (2017) used spatial econometric techniques to examine the distributional dynamics of regional income in Turkey during two separate periods (1987-2001 and 2004-2014). The results of the study showed that regional disparities are becoming permanent in Turkey.

Although they did not analyze the issue at the regional level, some studies have discussed endogenous growth under several scopes. Using the framework of the endogenous growth model, Cengiz Cihan and Dilip Dutta (2005) empirically analyzed the role of trade policies on output growth in Turkey from 1980 to 2000. They found that imports and education expenditure have a significant effect on economic growth.

Trade liberalization has also been analyzed from an endogenous growth perspective by Subrata Ghatak, Chris Milner, and Utku Utkulu (1995). They found a stable long-run relationship among real income, trade liberalization, physical capital, and human capital.

Aside trade liberalization issues, some studies have directly analyzed the relationship between human capital and economic growth. However, most of these studies did not conduct a regional analysis. For instance, Cuma Bozkurt (2015) dealt with the issue of human capital by explaining it with R&D expenditures. The empirical analysis showed that R&D expenditures have a positive impact on the economic growth of Turkey.

The relationship between R&D expenditures and the economic growth of Turkey has also been investigated by Kadir Tuna, Emir Kayacan, and Hakan Bektaş (2015). According to the empirical results of their study, there is no causal relationship between R&D expenditures and economic growth.

The causal relationship between R&D expenditures and economic growth has been investigated by Onur Altın and A. Ayşen Kaya (2009). Contrary to the results of the study of Tuna et al. (2015), they found that there is a long-run causality running from R&D expenditures to economic growth.

As the literature review shows, analyzing Turkey's regional income convergence with one of the leading models of the endogenous growth theory will greatly contribute to the current literature.

3. Background and Methodology

The aim of this study is to enrich the content of the empirical regional endogenous growth literature by investigating the effects of human capital on income convergence among regions of Turkey. At this point, we indicate the differences in per-capita income between the relatively high-income west and relatively low-income east by using available regional income data from the Turkish Statistical Institute (TURKSTAT). This situation is depicted in Figure 1. As Karaca (2004) did, the east–west classification is done according to the NUTS1 classification presented in Appendix A (see Figure 9; the NUTS1, NUTS2, and NUTS3 classifications are also presented).

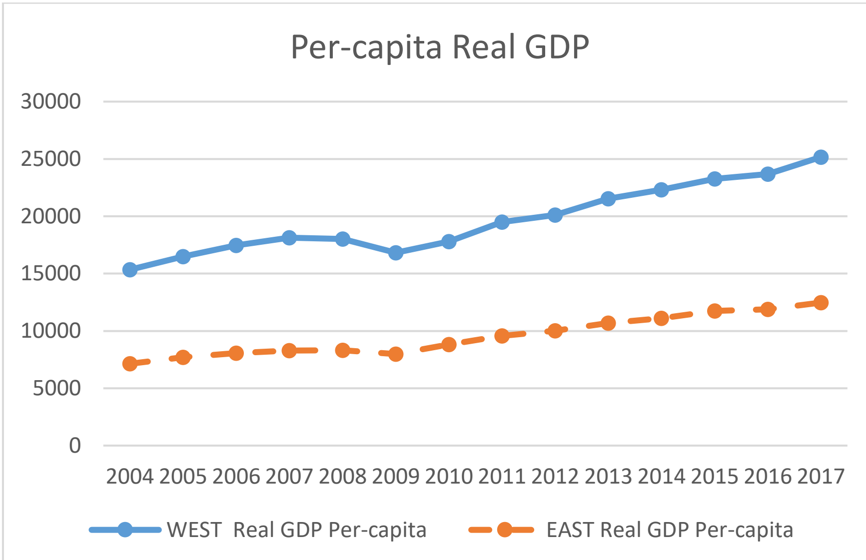

Figure 1 West vs. East (Per-capita Real GDP in TL (Turkish Lira))

Source: Author's own calculation based on data from TURKSTAT.

The income level differences between the high-income west and low-income east is a long-standing debate that requires not only a detailed economic analysis but also sociologic analysis, but this is not in the scope of this study. However, it is better to mention this issue superficially from historical and political perspectives. Regional policies have a very important place in Turkey's development plans. In the 3rd development plan (1973–1977), the definition of Priority Provinces for Development (PPD) emerged. The aim of PPD is to direct investment towards low-income areas to reduce regional disparities in Turkey. However, in time, due to political pressure, the number of provinces in which priority is given increased drastically. Therefore, this strategy became unsuccessful. Contrary to this strategy, after the 1980s, with the export-based development strategy, which is not in favor of reducing regional disparities, investment has mostly been directed towards metropolitan cities. After the 2000s, there have been great structural changes in the Turkish economy. As Refet Gürkaynak and Selin Sayek-Böke (2015) did, it would be useful to divide the post-2000 period into two, as 2002–2006 and 2007 onwards. During the first period, the requirements of the program were implemented according to the IMF program that the government took over from Kemal Derviş (Minister of Economy at the time). Although on paper, the IMF program ended in 2008, it actually ended in 2006. Compliance with the program achieved a growth of 7.2% in the first period (2002-

2006). However, it is better to state that this shows nothing about income distribution. In the second period, there was emphasis on medium-run programs rather than structural, long-term reforms. The coefficient of variation and the highest-lowest income ratio are used to measure the effects of the changes in regional income differences. In order for the methodologies to be consistent with the empirical result section, they were applied to NUTS1 regions of Turkey because, in the empirical section, the main variable analyzed is R&D personnel data, but it is only available at the NUTS1 level. The logarithm of real per-capita GDP data is used for both methodologies. The coefficient of variation is a better technique than the sigma convergence methodology because whereas the sigma convergence investigates the trend of standard deviation, the coefficient of variation investigates the ratio of standard deviation over the mean. Therefore, if there were large fluctuations, crises, booms, etc. (like what is the case for this study) during the research period, the sigma convergence methodology can produce biased results, whereas the coefficient of variation methodology can produce relatively robust results. A decreasing trend indicates convergence, whereas an increasing trend indicates divergence. The period for the descriptive statistics is 2004 to 2017 due to the lack of available regional data about Turkey. The results are given for Turkey as a whole as well as for the east and west regions. As depicted in Figure 2, the results of the coefficient of variation show that there is a decreasing trend in both the east and west regions as well as Turkey as a whole. However, the trends in the west and east regions are not as obvious as it is for Turkey as a whole. There was a decreasing trend during the global financial crisis (2008 crisis), but after the crisis, there was an increasing trend in the west and a fluctuating trend in the east. Moreover, for Turkey as a whole, the main factor for the decreasing trend is the crisis. As depicted in Figure 3, the highest–lowest income ratio indicates that there is a convergence due to the decreasing trend in both the east and west regions as well as Turkey as a whole. Again, the trend in the east and west regions is not as obvious as it is for Turkey as a whole. However, according to both the results of the coefficient of variation and the highest–lowest income ratio, it is difficult to state that there is convergence or divergence in NUTS1 level regions of Turkey. However, it is possible to state that crisis creates an undesirable convergence by affecting the west region more negatively. Moreover, the available, short period is not sufficient to indicate a convergence or divergence. However, it is certain that crisis creates a convergence.

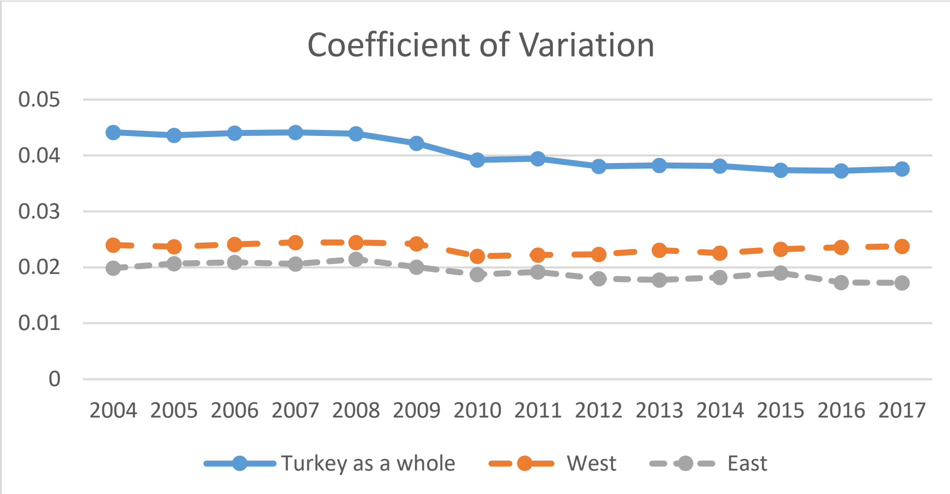

Figure 2 Coefficient of Variation Result at the NUTS1 level (logarithm of Per-capita Real GDP in TL (Turkish Lira))

Source: Author's own calculation based on data from TURKSTAT.

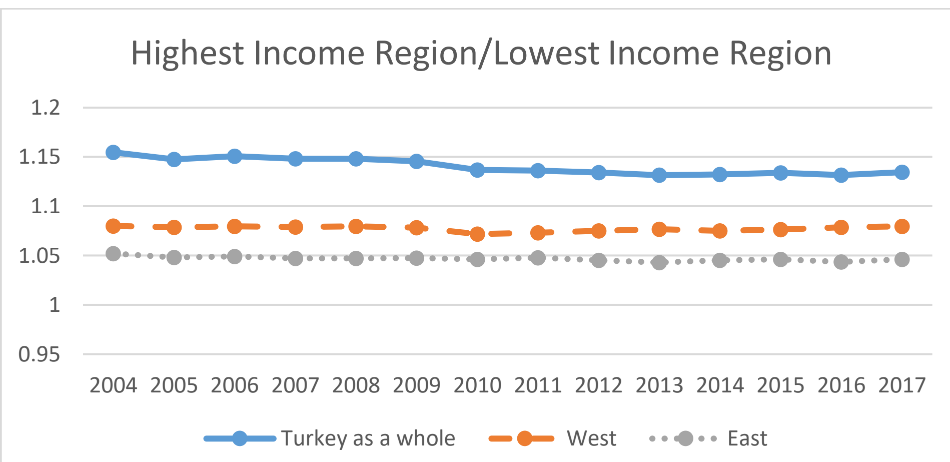

Figure 3 Highest–Lowest Income Ratio Result at NUTS1 level (logarithm of Per-capita Real GDP in TL (Turkish Lira))

Source: Author's own calculation based on data from TURKSTAT.

In order to adhere to the scope of this study, only the human capital aspect of the issue about closing the regional income disparities will be examined.

The empirical model is from the study of Romer (1990). Since within-country analysis is made, other models that are related to the diffusion of technology via international trade, such as those presented in the studies of Grossman and Helpman (1990, 1991, 1993, 1994), Coe and Helpman (1995), and Coe et al. (1997), are not applicable. Moreover, the Schumpeterian perspective is not applicable because the period of this study is not too long to use such a perspective.

Furthermore, the main aim is to analyze the effect of human capital on income convergence among regions of Turkey, so having a specified model that focuses on this issue is more applicable. Therefore, the model is taken from the study of Romer (1990) because it is the best model that serves the purpose of this study.

The original model from the study of Romer (1990) is given below. In the equation, L_A represents labors in the research sector (human capital); δ represents productivity parameter, and $\frac{\dot{A}}{A}$ represents the growth of knowledge. As shown in the equation, growth of knowledge, that is, economic growth (from the endogenous growth perspective) is based on human capital, which is defined as R&D personnel.

$$\frac{\dot{A}}{A} = \delta L_A \quad (1)$$

The left-hand side of the equation can be called the TFP growth. However, due to the data problem about TFP at the regional level, instead of TFP growth, GDP growth is used because the main ideology in the study of Romer (1990) is that technological change lies at the heart of economic growth. Therefore, since TFP can be used as a proxy for technological progress, per-capita real GDP growth can be used as a proxy for TFP growth. Furthermore, the aim of this study is to investigate the income convergence issue for Turkey at the regional level; that is why using per capita real GDP growth is more suitable. Therefore, henceforth, in equations, the term “Y” instead of “A” will be used.

The main problem of Romer’s (1990) model is the scale effect. To illustrate this point, according to Equation (1), when both the economy and labor force or population grow, the number of labors in the research sector also increases, and this situation can affect the result. Charles I. Jones (1995a, b) criticized this issue because he found that it is inconsistent with the results of his works about some developed countries. For example, as Izushi (2008) also mentioned, in the USA, the number of labors in the research sector increased fivefold from 1950 to 1987 due to population growth and an increase in the intensity of R&D, whereas productivity growth remained relatively constant.

To solve the problem of the scale effect of Romer’s (1990) model, the idea of increasing product varieties is used. Aghion and Howitt (1998), Howitt (1999), and Alwyn Young (1998) stated that economic growth increases product varieties. Therefore, the scale effect is neutralized by increasing product varieties as the economy grows. Product differentiation is assumed to increase in proportion to the labor force (L) (Izushi, 2008). Thus, Equation (1) can be rewritten as follows:

$$\frac{\dot{Y}}{Y} = \alpha + \delta\frac{L_A}{L} \quad (2)$$

In Equation (2), the scale effect problem is eliminated by dividing labor in the research sector with the overall labor force (L).

Moreover, since this work is related to income convergence, the model is also modified according to the following catch-up condition:

$$\frac{\dot{Y}}{Y} = \alpha + \gamma\frac{L_A}{L}\frac{Y_l - Y_r}{Y_r} \quad (3)$$

The aim is how a catch-up strategy that is based on an increase in the ratio of R&D personnel to total employment will affect the growth of a region. Y_l represents the per-capita real GDP of the leading region (for every period, it is Istanbul), whereas Y_r represents the regions' per-capita real GDP. This equation indicates that the speed of catch-up is determined by the ratio of R&D personnel to total employment $\left(\frac{L_A}{L}\right)$. Moreover, to eliminate the scale effect problem, R&D personnel is divided by total employment.

Regarding the data on Turkey, the R&D personnel data are only available at the NUTS1 level and from 2010 to 2017. The new regional level GDP data is only available from 2004 to 2017. Therefore, there are 12 cross-sections and only eight years (2010–2017), implying that only 96 observations were used for the analysis. To cope with this problem, the ratio of R&D personnel to total employment is transferred from NUTS1 to NUTS2 level. In the NUTS2 classification, the same value is given to the regions that are in the same group in the NUTS1 level. This is not a big problem because this study uses a share variable. Moreover, using the ratio of R&D personnel eliminates the scale effect problem. Finally, the equation below is tested in the NUTS2 level regions of Turkey.

$$\frac{\dot{Y}}{Y} = \alpha + \delta SHL_A \quad (4)$$

SHL_A represents the ratio of R&D personnel to total employment. Furthermore, NUTS2 (26 regions) analysis expands the sample size to 208.

Moreover, to investigate whether an increase in the ratio of R&D personnel decreases the growth differences of per-capita income among regions, the dependent variable is modified by subtracting the growth of Turkey from the growth of the region. The equation is as follows:

$$\left(\frac{\dot{Y}}{Y}\right)_r - \left(\frac{\dot{Y}}{Y}\right)_{TR} = \alpha + \delta SHL_A \quad (5)$$

This issue is also investigated at the NUTS2 level using a transformed share variable. The negative and significant coefficient of the independent variable implies that an increase in the ratio of R&D personnel to total employment decreases the differences between the growth of per-capita income among the regions.

Furthermore, to analyze the quadratic relationship between R&D personnel and economic growth of the regions, the equation below is also constructed.

$$\frac{\dot{Y}}{Y} = \alpha + \gamma(\text{SHLA})^2 + \delta\text{SHLA} \tag{6}$$

To control for the endogeneity that can be caused by omitted variable bias, a period lag of the dependent variable is added to the equation by constructing a dynamic model.

$$\left(\frac{\dot{Y}}{Y}\right)_{it} = \alpha + \gamma\left(\frac{\dot{Y}}{Y}\right)_{it-1} + \beta(SHLA)_{it} \tag{7}$$

All the data are from TURKSTAT. Since real GDP is not announced at the regional level, the income data are converted into real terms by using the GDP deflator of Turkey. CPI is not preferred because the GDP deflator is more comprehensive, and CPI data at the regional level is only available for NUTS2 level regions of Turkey. It is not reported, but the standard deviation and average growth rate of CPI at the NUTS2 level are investigated, and since no significant differences were found among the regions at the NUTS2 level, the GDP deflator is used to convert the data into real terms.

Furthermore, because the period is limited (small T), unit root tests are not applied, and only the problem of heteroskedasticity is checked as a diagnostic test because Badi Baltagi (2008) stated that serial correlation and cross-sectional dependence are problems associated with macro panels with long time series (over 20–30 years). The problem of heteroskedasticity is corrected using robust standard errors.

Aside dynamic models, fixed-effects models are used because this study conducts regional analysis, and every individual unit of the entire sample is used in the analysis. Therefore, variations within the regions have to be considered. Additionally, the Hausman tests support this argument by proposing fixed-effects regressions.

It is important to note that spatial analysis is not added to the empirical analysis because although some modifications are made in the empirical analysis, R&D personnel data are only at the NUTS1 (12 regions) level, so it is inappropriate (distances are not enough to create interaction among the regions) to include spatial analysis. Thus, this was not ignored just by intuition. Exploratory spatial data analysis (ESDA) was conducted before the empirical analysis. Spatial autocorrelation at the NUTS1 level was tested using Moran's I and Geary's C. Since Luc Anselin

(1993) criticized Moran's I, stating that it is a global measure that can give biased results about spatial autocorrelation, the local indicators of spatial association (LISA) methodology proposed by Anselin (1995) was also applied at the NUTS1 level. The test statistics indicate that there is no evidence of spatial autocorrelation. This is not surprising because it is challenging to discuss spatial ties in large areas (Turkey is 783,562 square kilometers). It may give significant results at NUTS2 (26 regions) and NUTS3 (81 provinces) regions, but unfortunately, R&D personnel data is only available for NUTS1 (12 regions) regions of Turkey. Thus, spatial analysis was not included in the empirical analysis of this study.

4. Empirical Results

As explained in the previous section, the modified version (elimination of scale effect problem by dividing R&D personnel with the total employment) of Romer's (1990) model is used to investigate the income convergence by analyzing the effect of human capital on the growth performance of the regions. The results presented in Table 1 show that R&D personnel has a negative and significant effect on the economic growth performance of the regions.

Table 1 Regression Results for Model (2)

Fixed-effects regression **Number of observations:** 96 **Number of groups:** 12 **Dependent Variable:** $\frac{\dot{Y}}{Y}$	
Independent Variables	**Coefficient**
$\frac{L_A}{L}$	-14.9361*** (-4.42) [3.3755]
Cons	0. 1624*** (6.65) [0.0244]
Prob > F = 0.0010; **R-squared (within) =** 0.2228; **Result:** Negative effect	

t statistics are in ( ); robust standard errors are in [ ]; ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

Source: Author's own calculation based on data from TURKSTAT.

Because this study is about income convergence, it is better to investigate the effect of human capital as an engine for convergence. The results reported in Table 2 show that a convergence strategy that is based on an increase in the ratio of R&D personnel in total employment has a negative impact on convergence since this strategy has a negative impact on the economic growth of the regions.

Table 2 Regression Results for Model (3)

Fixed-effects regression **Number of observations:** 96 **Number of groups:** 12 **Dependent Variable:** $\frac{\dot{Y}}{Y}$	
Independent Variables	**Coefficient**
$\frac{L_A}{L}\frac{Y_l - Y_r}{Y_r}$	-12.2309*** (-4.44) [2.7551]
Cons	0. 1365*** (7.38) [0.0185]
Prob > F = 0.0010; **R-squared (within) =** 0.2728; **Result:** Negative effect	

t statistics are in ( ); robust standard errors are in [ ]; ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

Source: Author's own calculation based on data from TURKSTAT.

To increase the sample size, the ratio of R&D personnel to total employment is transferred from NUTS1 to NUTS2, but it does not change the result. The results presented in Table 3 show that the ratio of R&D personnel to total employment has a negative and significant impact on economic growth in the regions.

Table 3 Regression Results for Model (4)

Fixed-effects regression **Number of observations:** 208 **Number of groups:** 26 **Dependent Variable:** $\frac{\dot{Y}}{Y}$	
Independent Variables	**Coefficient**
SH L_A	-0.1765*** (-6.72) [0.0263]
Cons	0.1758*** (9.81) [0.0179]
Prob > F = 0.0000; **R-squared (within) =** 0.2080; **Result:** Negative effect	

t statistics are in ( ); robust standard errors are in [ ]; ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

Source: Author's own calculation based on data from TURKSTAT.

Based on the scope of this study, to capture the effect of R&D personnel on regional growth differences in income, the dependent variable is modified by subtracting the growth of Turkey from a region's growth. In this case, the negative coefficient of the dependent variable is an indicator of the convergence of the differences in the growth among the regions. The results presented in Table 4 show that an increase in the ratio of R&D personnel to total employment closes the gap in the differences in the regional growth.

Table 4 Regression Results for Model (5)

Fixed-effects regression **Number of observations:** 208 **Number of groups:** 26 **Dependent Variable:** $\left(\frac{\dot{Y}}{Y}\right)_r - \left(\frac{\dot{Y}}{Y}\right)_{TR}$	
Independent Variables	**Coefficient**
SH L_A	-0.0403** (-2.16) [0.0186]
Cons	0.0289** (2.27) [0.0127]
Prob > F = 0.0406; **R-squared (within) =** 0.0193; **Result:** Negative effect	

t statistics are in ( ); robust standard errors are in [ ], ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

Source: Author's own calculation based on data from TURKSTAT.

However, it is appropriate to mention the part (east or west) of the country that had the highest growth rates of per-capita real income during the research period. The growth rates of the east and west regions are presented in Table 5. According to Table 5, the growth rate of the relatively low-income east is more than that of the relatively high-income west. Therefore, an increase in the ratio of R&D personnel to total employment decreases the differences in the growth among the regions, but it affects the east region more negatively. To prove this finding, it is essential to analyze this issue using two different regressions (regressions for west and east) that examine the effect of the ratio of R&D personnel to total employment on economic growth in the regions and investigate the trends. As depicted in Figures 4 and 5, the negative effect is more valid in the east region. Regarding the west region, the effect of R&D personnel on economic growth is also negative, but it can become positive if the ratio increases a little bit more.

Table 5 Growth Rates (%) of Per-Capita GDP (West-East)

year	West	East
2010	5.7767	10.5340
2011	9.5427	8.6295
2012	3.1427	4.5083
2013	7.0605	6.8100
2014	3.6018	3.7914
2015	4.2875	5.6950
2016	1.8302	1.2963
2017	6.2521	4.9298
Average	**5.1868**	**5.7743**

Source: Author's own calculation based on data from TURKSTAT.

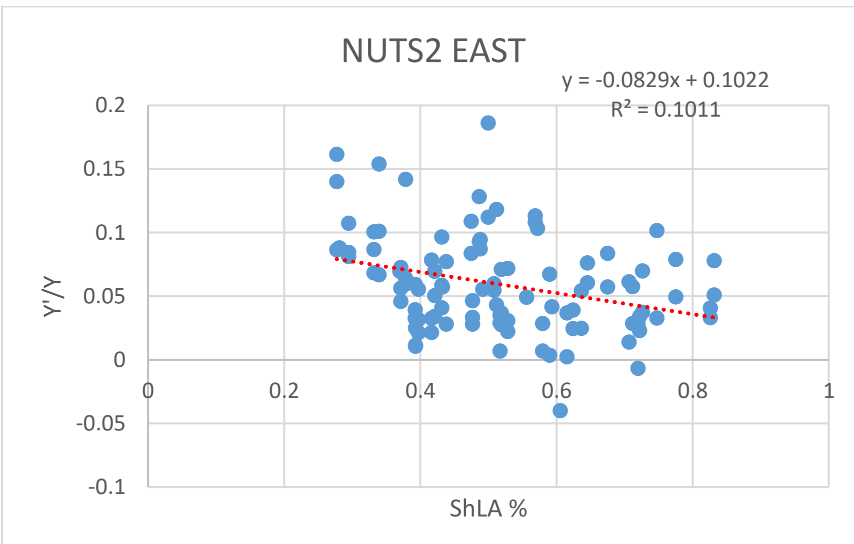

Figure 4 Scatter Plot (1)

Source: Author's own calculation based on data from TURKSTAT.

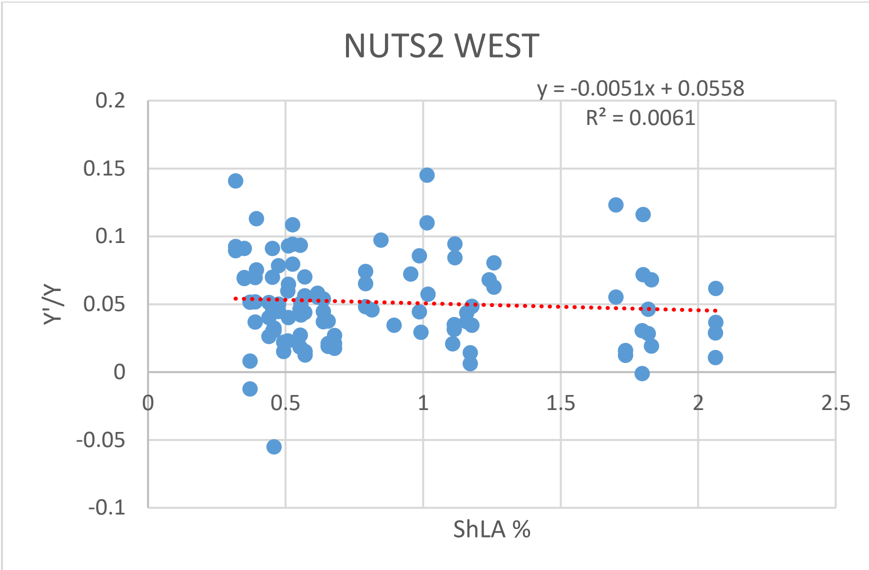

Figure 5 Scatter Plot (2)

Source: Author's own calculation based on data from TURKSTAT.

Moreover, the reason why the east region is more negatively affected by an increase in the ratio of R&D personnel to total employment is that the effect may not become positive before it reaches a certain level. This situation can be understood by using the ratio of R&D personnel to total employment in the east and west. As presented in Table 6, the ratio of R&D personnel to total employment in the west is much more than that of the east. Therefore, if the ratio increases, the negative impact will be closer to becoming positive in the west than in the east. Thus, it is estimated that there is a U-shaped relationship between the ratio of R&D personnel to total employment and economic growth in the regions. This situation is depicted in Figure 6. The west region is on the less negatively sloped side, whereas the east region is on the more negatively sloped side. The figure depicts that the effect will not become positive before reaching a certain level regardless of the growth rates of the regions.

Table 6 Percentage (%) of R&D Personnel (West-East)

year	West	East
2010	0.7779	0.3625
2011	0.7975	0.4106
2012	0.8501	0.4818
2013	0.8794	0.5009
2014	0.9346	0.5509
2015	0.9537	0.5697
2016	1.0153	0.5777
2017	1.0930	0.5766
Average	**0.9127**	**0.5038**

Source: Author's own calculation based on data from TURKSTAT.

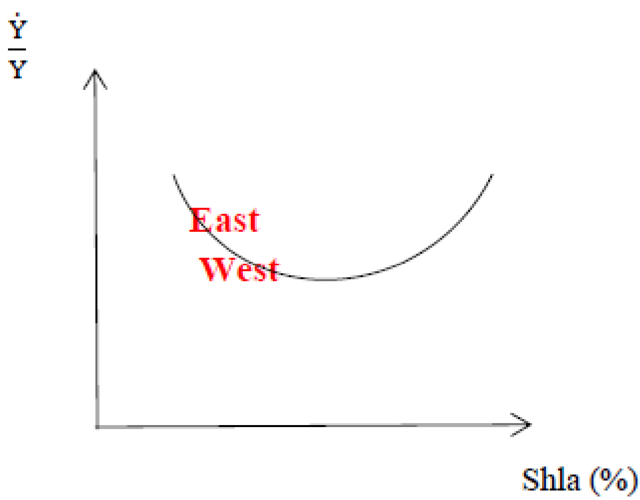

Figure 6 Estimated U-Shaped Figure of the Relationship between Economic Growth and the Ratio of R&D Personnel to Total Employment

Source: Author's own estimation.

To prove the U-shaped relationship between the ratio of R&D personnel to total employment and economic growth in the regions, the ratio is squared and included in the regression as an independent variable. This study has already found that the coefficient of the share variable is negative and significant, but the coefficient of the square of the share variable needs to be positive for the U-shaped relationship between the ratio of R&D personnel to total employment and economic growth in the regions. According to the results presented in Table 7, the square of the ratio has a positive and significant coefficient, whereas the coefficient of the share variable remains negative and significant. This result supports the estimation of the U-shaped relationship.

Table 7 Regression Results for Model (6)

Fixed-effects regression **Number of observations:** 208 **Number of groups:** 26 **Dependent Variable:** $\frac{\dot{Y}}{Y}$	
Independent Variables	**Coefficient**
$(\mathrm{SHLA})^2$	0.0775*** (3.70) [0.0209]
SHLA	-0.3083*** (-7.38) [0.0418]
Cons	0.2169*** (11.56) [0.0188]
Prob > F = 0.0000; **R-squared (within)** = 0.2499; **Result:** Convex shape (U-shaped)	

t statistics are in ( ); robust standard errors are in [ ]; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Source: Author's own calculation based on data from TURKSTAT.

To capture the turning point, a quadratic prediction plot that is constructed using fitted values is presented in Figure 7. This situation is depicted with a 95% confidence interval (based on the standard error of the mean) in Figure 7 and with a scatter plot and 95% confidence interval (based on the standard error of the forecast that is mostly used to investigate whether the majority of observations are in the confidence interval) in Figure 8. Figure 7 depicts that the real values are in the confidence interval. Figure 8 shows that majority of the observations are in the confidence interval. These demonstrate the robustness of the results.

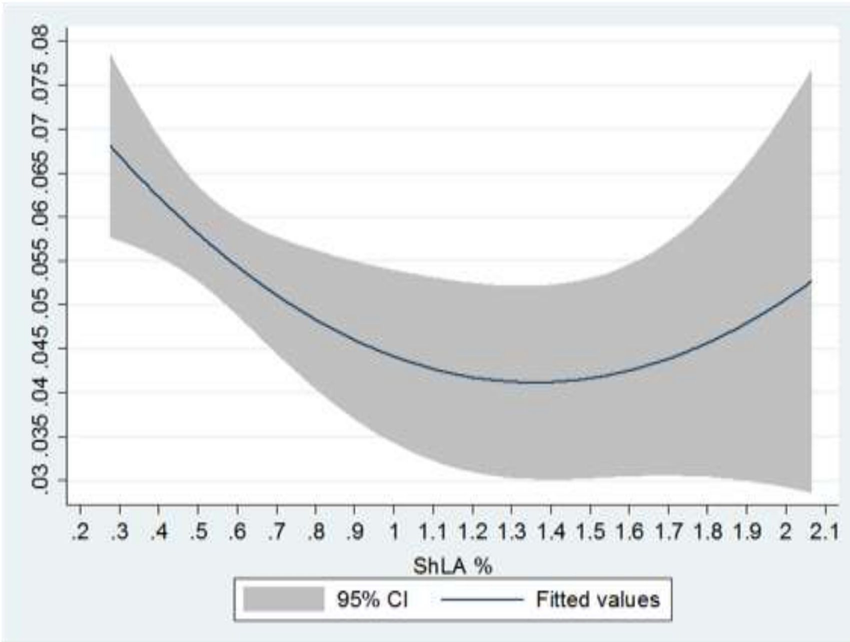

Figure 7 Quadratic Prediction Plot with a 95% CI (based on the standard error of the mean)

Source: Author’s own calculation based on data from TURKSTAT.

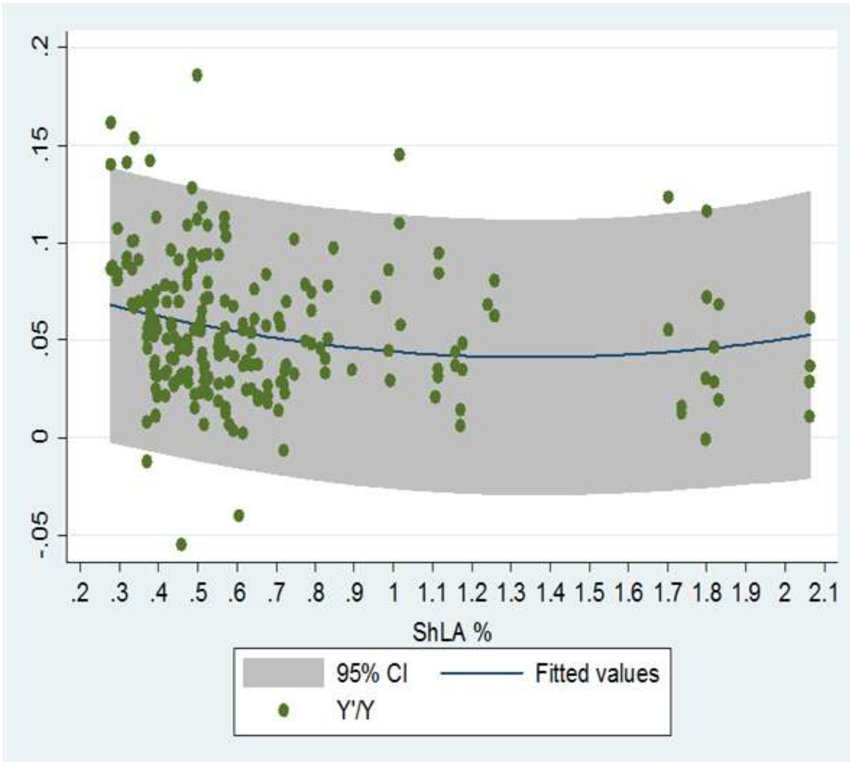

Figure 8 Quadratic Prediction Plot with a Scatter Plot and 95% CI (based on the standard error of the forecast)

Source: Author's own calculation based on data from TURKSTAT.

As depicted in the figures, the predicted turning point is 1.3576% for the ratio of R&D personnel to total employment and 4.1179% for economic growth. The average ratio of R&D personnel to total employment in the research period (2010-2017) is 0.7935%. This point coincides with the 4.8500% economic growth on the quadratic fitted line. The actual average growth in the research period (2010-2017) is 5.4018%, which is in the confidence interval when either the standard error of the forecast or the mean is used. Therefore, the predicted turning point of 1.3576% for the ratio of R&D personnel to total employment is meaningful.

Other factors affect per-capita GDP growth. However, because of the degrees of freedom problem, other factors cannot be directly added to the model as independent variables (i.e., omitted variable bias, which is one of the sources of endogeneity). Therefore, instead of using various variables, the lagged dependent variable is used as one of the predictors of the model because it includes all other factors. The unobserved panel-level effects are correlated with the lagged dependent variables, which makes the standard estimator inconsistent (in static models, using a lagged dependent variable leads to autocorrelation). Therefore, it is necessary to construct a dynamic panel data model (dynamic models make robust estimates of all sources of endogeneity, such as omitted variable, reverse causality, and measurement error), which includes p lags of the dependent variable as covariates and contains unobserved panel-level effects, whether fixed or random.

Arellano-Bond dynamic panel-data estimation two-step difference generalized method of moments (GMM) is used to investigate this issue in NUTS2 level regions of Turkey with transformed share variable from 2010 to 2017. Arellano-Bond estimator is appropriate for this study (t=6; 2010 and 2011 are eliminated because of instruments). According to Manuel Arellano and Stephen Bond (1991), the Arellano-Bond estimator uses the second lag of the dependent variable and all feasible lags thereafter (detailed information is presented in Appendix B; N=26) since it was designed for panels with small T and relatively large N. Other modified methodologies have been derived from the Arellano-Bond procedure. However, it is not because it has several deficiencies rather it is because of the difficulty of finding robust results. This procedure is not flexible, implying that the number of instrumental variables cannot be changed according to one's wants. Although later versions provide this option, in my opinion, this goes against the organizational structure of the model. I think it makes it easier to achieve the desired results. Therefore, Arellano-Bond dynamic panel-data estimation is used instead of other methods derived from it. Furthermore, there is no need to modify the methodology as it provides robust results for the empirical analysis. A two-step estimator uses the first step estimates to estimate the parameters of interest. Although a two-step estimator is asymptotically more efficient than a one-step estimator, its standard errors are downward biased. However, it is possible to cope with this problem. Therefore, Frank Windmeijer (2005) developed a finite sample correction matrix that makes two-step robust GMM estimates more efficient than one-step robust estimates, as David Roodman (2009) also mentioned. Therefore, using the biased-corrected standard errors (WC-robust standard errors) developed by Windmeijer, this study reports the results of the two-step difference GMM. In addition, to check the robustness of the results and make a comparison, one-step difference GMM results (while all other conditions are the same) are also presented in Appendix B, and the interpretation of the results did not change, which proves the robustness of the results.

Moreover, classical difference GMM is preferred to system GMM in which lagged differences are used as moment conditions for level and differenced equations. When GMM-type instruments are added to the level equation, system GMM has more instruments than difference GMM. The number of instruments (the technical details related to the instruments in the current model—Arellano-Bond dynamic panel-data estimation difference GMM—are presented in Appendix B) may be larger than the number of groups, and the suggested rule of thumb is to keep the number of instruments equal to or smaller than the number of groups. However, this study has a limited number of groups (N=26). When system GMM is used, the number of instruments will be more than the number of groups, so difference GMM is used.

When using a GMM estimator, the moment conditions must be valid before consistent estimates can be obtained. There is no direct way to test this but the validity of overidentifying conditions can be tested. Sargan test and Hansen test can be used for this purpose. In a two-step GMM, the standard procedure is to use the Hansen test (Roodman, 2009). The distribution of the Sargan test is not known when the disturbances are heteroskedastic, so this test cannot be used with robust standard errors, but biased-corrected standard errors (WC-robust standard errors) are used because a two-step estimator is employed. Therefore, instead of using the Sargan test, the Hansen test is used because it is robust to non-i.i.d. (independently and identically distributed) errors. The results of the Hansen test indicate that the instruments are valid. However, the moment conditions are valid only if there is no serial correlation in the idiosyncratic errors. The Arellano-Bond Test is used to test for serial correlation in the first-differenced errors. Rejecting the null hypothesis of no serial correlation at order one in the first differenced errors does not imply that the model is misspecified because the first difference of i.i.d. idiosyncratic errors must be autocorrelated. However, rejecting the null hypothesis at order two indicates that the moment conditions are not valid. Therefore, for the robustness of the model, there must be autocorrelation at order one (the first-differenced errors are first-order serially correlated when the idiosyncratic errors are i.i.d.) and no autocorrelation at order two. The results of the Arellano-Bond Test indicate that this requirement has been met. Thus, the Hansen and Arellano-Bond tests prove that the moment conditions are valid.

The estimation results presented in Table 8 confirms that the ratio of R&D personnel to total employment affects the regions' GDP per-capita growth negatively, as found in other models. Moreover, all the coefficients and models are statistically significant. In the dynamic model, the potential endogeneity problem is controlled, and the results prove that the ratio of R&D personnel to total employment has a negative effect on economic growth in the regions.

Table 8 Regression Results for Model (7)

Arellano-Bond dynamic panel-data estimation two-step difference GMM **Number of observations:** 156 **Number of Groups:** 26 **Number of instruments:** 23 **Dependent Variable:** $\left(\frac{\dot{Y}}{Y}\right)_t$	
Independent Variables	**Coefficient**
$\left(\frac{\dot{Y}}{Y}\right)_{t-1}$	-0.2219*** (-3.03) [0.0732]
SHLA	-0.2288*** (-5.51) [0.0415]
Cons	0.2210*** (6.17) [0.0358]
Prob > chi2 = 0.0000; **Wald chi2(2)** = 31.86; **Result:** Negative effect	
Hansen test of overidentifying restrictions **H0: overidentifying restrictions are valid** chi2(20) = 24.17; Prob > chi2 = 0.235	
Arellano-Bond test for zero autocorrelation in first-differenced errors	

Order	**z**	**Prob > z**
1	-3.17	0.002
2	-0.29	0.771

H0: no autocorrelation

Note: Because the first difference of white noise is necessarily autocorrelated, one needs to care about the second order.

z statistics are in ( ), WC-robust standard errors are in [ ], ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Source: Author's own calculation based on data from TURKSTAT.

Table 9 provides a summary of the results of different models.

Table 9 Summary Table

Models	Results
$\frac{\dot{Y}}{Y} = \alpha + \delta\frac{L_A}{L}$	R&D personnel has a negative impact on economic growth in the regions.
$\frac{\dot{Y}}{Y} = \alpha + \gamma\frac{L_A}{L}\frac{Y_l - Y_r}{Y_r}$	The catch-up strategy based on increasing the ratio of R&D personnel to total employment has a negative impact on economic growth in the regions.
$\frac{\dot{Y}}{Y} = \alpha + \delta SHL_A$	The ratio of R&D personnel to total employment has a negative impact on economic growth in the regions.
$\left(\frac{\dot{Y}}{Y}\right)_r - \left(\frac{\dot{Y}}{Y}\right)_{TR} = \alpha + \delta SHL_A$	An increase in the ratio of R&D personnel to total employment closes the growth differences among the regions.
$\frac{\dot{Y}}{Y} = \alpha + \gamma(SHLA)^2 + \delta SHLA$	There is a U-shaped (convex) relationship between R&D personnel and economic growth in the regions. Thus, it is estimated that after a certain level, the effect will be positive.
$\left(\frac{\dot{Y}}{Y}\right)_{it} = \alpha + \gamma\left(\frac{\dot{Y}}{Y}\right)_{it-1} + \beta(SHLA)_{it}$	Controlling for endogeneity does not change the result that indicates that the ratio of R&D personnel to total employment has a negative impact on economic growth in the regions.

5. Conclusion

In this study, the convergence issue among the regions of Turkey is investigated from the perspective of endogenous growth.

According to the results, the ratio of R&D personnel to total employment has a negative impact on economic growth in the regions. Moreover, a catch-up strategy that is based on increasing the ratio of R&D personnel to total employment has a negative impact on economic growth in the regions. Furthermore, during the research period, the east region grew more than the west region and increasing the ratio of R&D personnel to total employment decreases the growth differences between the regions because it affects the east region more negatively. At this point, it is important to note that it is a closure of the differences in the growth rates, and it has a negative impact, which is not desirable. Moreover, aside growth rates, this situation prevents the low-income east to catch up with the high-income west in terms of per-capita income. This is because to reach a catch-up condition, the east region needs to grow more than the west region, and increase in the ratio of R&D personnel to total employment has a negative effect on the catch-up condition in the current situation.

Moreover, this study finds that there is an estimated U-shaped relationship, implying that if the percentage of R&D personnel in total employment increases, after a certain level, the effect has a tendency of turning to positive, especially the west region is closer to reaching that. Currently, the reason for the negative effect of R&D personnel on economic growth in the regions may be that before reaching a certain level of R&D personnel, subsidies and expenditures on R&D yield no results. To have the positive effect of R&D personnel, it is essential to create a suitable research environment because, in R&D, interactions and externalities are very significant. Therefore, unless the ratio of R&D personnel to total employment reaches a satisfactory level, it is impossible to reap the benefits of research activities.

Regarding the convergence issue, the high-income west is closer to having the positive effect of R&D personnel, and because the east region has a relatively low percentage of R&D personnel, its economic growth is more negatively affected by R&D personnel. With its current percentage of R&D personnel, using a strategy that is based on increasing the percentage of R&D personnel will not help the east region to close the difference between its income and that of the west region in the short run. Moreover, in the medium and long run, this strategy can be unsuccessful because, as mentioned in the “cities and growth” section of Lucas (1988), there is an interaction and externality effect, which prevents the east region from leading the west region in the ratio of R&D personnel to total employment. This means that although the effect of R&D personnel will become positive, the possibility of having a higher percentage of R&D personnel than the west region is very low for the east region. Subsidies also cannot solve this issue because human capital does not move just because of higher wages, as there is an externality feature of human capital.

According to the results, the east region is far from enjoying the positive effect of R&D personnel. If the convergence policy, which is based on increasing the percentage of R&D personnel in the east region, is applied, it may cause divergence rather than convergence. Therefore, although it is not in the scope of this study, focusing on policies in which the east region has a comparative advantage can be more beneficial in closing the income disparities between the west and east regions.

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Appendix A

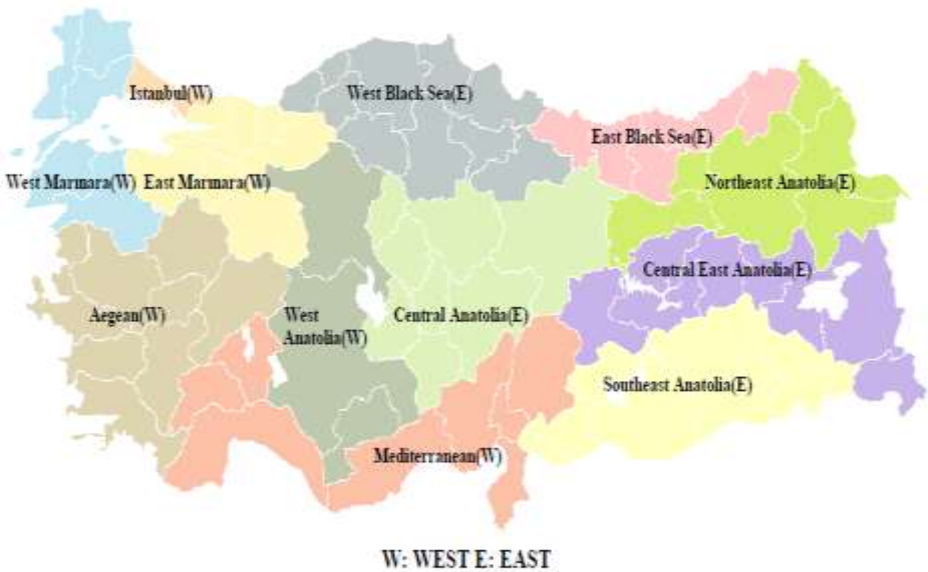

Figure 9 East-West Classification

Source: Author's own work.

Table 10 NUTS1, NUTS2, and NUTS3

NUTS1	NUTS2	NUTS3
İstanbul	İstanbul	İstanbul
West Marmara	Tekirdağ, Edirne, Kırklareli	Tekirdağ
		Edirne
		Kırklareli
	Balıkesir, Çanakale	Balıkesir
		Çanakkale
Aegean	İzmir	İzmir
	Aydın, Denizli, Muğla	Aydın
		Denizli
		Muğla
	Manisa, Afyonkarahisar, Kütahya, Uşak	Manisa
		Afyonkarahisar
		Kütahya
		Uşak
East Marmara	Bursa, Eskişehir, Bilecik	Bursa
		Eskişehir
		Bilecik
	Kocaeli, Sakarya, Düzce, Bolu, Yalova	Kocaeli
		Sakarya
		Düzce
		Bolu
		Yalova
West Anatolia	Ankara	Ankara
	Konya, Karaman	Konya
		Karaman
Mediterranean	Antalya, Isparta, Burdur	Antalya
		Isparta
		Burdur
	Adana, Mersin	Adana
		Mersin
	Hatay, Kahramanmaraş, Osmaniye	Hatay
		Kahramanmaraş
		Osmaniye
Central Anatolia	Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir,	Kırıkkale
		Aksaray
		Niğde
		Nevşehir
		Kırşehir
	Kayseri, Sivas, Yozgat	Kayseri
		Sivas
		Yozgat

NUTS1	NUTS2	NUTS3
West Black Sea	Zonguldak, Karabük, Bartın	Zonguldak
		Karabük
		Bartın
	Kastamonu, Çankırı, Sinop	Kastamonu
		Çankırı
		Sinop
	Samsun, Tokat, Çorum, Amasya	Samsun
		Tokat
		Çorum
		Amasya
East Black Sea	Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane	Trabzon
		Ordu
		Giresun
		Rize
		Artvin
		Gümüşhane
North East Anatolia	Erzurum, Erzincan, Bayburt	Erzurum
		Erzincan
		Bayburt
	Ağrı, Kars, Iğdır, Ardahan	Ağrı
		Kars
		Iğdır
		Ardahan
Central East Anatolia	Malatya, Elazığ, Bingöl, Tunceli	Malatya
		Elazığ
		Bingöl
		Tunceli
	Van, Muş, Bitlis, Hakkari	Van
		Muş
		Bitlis
		Hakkari
South East Anatolia	Gaziantep, Adıyaman, Kilis	Gaziantep
		Adıyaman
		Kilis
	Şanlıurfa, Diyarbakır	Şanlıurfa
		Diyarbakır
	Mardin, Batman, Şırak, Siirt	Mardin
		Batman
		Şırnak
		Siirt
Total: 12	Total: 26	Total: 81

Source: TURKSTAT

Appendix B

Dynamic Model

Information about Instruments

Table 11 presents detailed information about the instruments of the model (Arellano-Bond dynamic panel-data estimation difference GMM).

Table 11 Detailed information about GMM-type instruments of the differenced equation

year	GMM-type Instruments
Information: For instruments, Arellano and Bond estimator uses the second lags of the dependent variable and all feasible lags thereafter (instruments cannot be correlated with error term ε_{it}(t), so it cannot start from time t. Thus, for differenced equation, it cannot start from time $t-1$. Therefore, the instruments start from $t-2$). **Note:** Sample: 2010-2017	
t=2017	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2015}, \left(\frac{\dot{Y}}{Y}\right)_{t-3}=\left(\frac{\dot{Y}}{Y}\right)_{2014}, \left(\frac{\dot{Y}}{Y}\right)_{t-4}=\left(\frac{\dot{Y}}{Y}\right)_{2013}, \left(\frac{\dot{Y}}{Y}\right)_{t-5}=\left(\frac{\dot{Y}}{Y}\right)_{2012}, \left(\frac{\dot{Y}}{Y}\right)_{t-6}=\left(\frac{\dot{Y}}{Y}\right)_{2011}, \left(\frac{\dot{Y}}{Y}\right)_{t-7}=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
t=2016	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2014}, \left(\frac{\dot{Y}}{Y}\right)_{t-3}=\left(\frac{\dot{Y}}{Y}\right)_{2013}, \left(\frac{\dot{Y}}{Y}\right)_{t-4}=\left(\frac{\dot{Y}}{Y}\right)_{2012}, \left(\frac{\dot{Y}}{Y}\right)_{t-5}=\left(\frac{\dot{Y}}{Y}\right)_{2011}, \left(\frac{\dot{Y}}{Y}\right)_{t-6}=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
t=2015	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2013}, \left(\frac{\dot{Y}}{Y}\right)_{t-3}=\left(\frac{\dot{Y}}{Y}\right)_{2012}, \left(\frac{\dot{Y}}{Y}\right)_{t-4}=\left(\frac{\dot{Y}}{Y}\right)_{2011}, \left(\frac{\dot{Y}}{Y}\right)_{t-5}=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
t=2014	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2012}, \left(\frac{\dot{Y}}{Y}\right)_{t-3}=\left(\frac{\dot{Y}}{Y}\right)_{2011}, \left(\frac{\dot{Y}}{Y}\right)_{t-4}=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
t=2013	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2011}, \left(\frac{\dot{Y}}{Y}\right)_{t-3}=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
t=2012	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
Total	21 GMM-type instruments for the differenced equation. **Note:** with "D.SHLA" (first difference of the regressor SHLA; standard instrument for differenced equation) and "constant" (standard instrument for level equation), in total the model has **23 instruments.**

Robustness Check with One-step Estimation

Table 12 Alternative Regression Results for Model (7)

Arellano-Bond dynamic panel-data estimation, One Step Difference GMM **Number of observations:** 156 **Number of Groups:** 26 **Number of instruments:** 23 **Dependent Variable:** $\left(\frac{\dot{Y}}{Y}\right)_t$	
Independent Variables	**Coefficient**
$\left(\frac{\dot{Y}}{Y}\right)_{t-1}$	-0.2166*** (-2.93) [0.0740]
SHLA	-0.2206*** (-6.11) [0.0361]
Cons	0.2167*** (6.77) [0.0320]
Prob > chi2 = 0.0000; **Wald chi2(2)** = 38.53; **Result:** Negative effect	
Hansen test of overidentifying restrictions **H0: overidentifying restrictions are valid** chi2(20) = 24.17; Prob > chi2 = 0.235	

Arellano-Bond test for zero autocorrelation in first-differenced errors

Order	**z**	**Prob > z**
1	-4.00	0.000
2	-0.22	0.826

H0: no autocorrelation

Note: Because the first difference of white noise is necessarily autocorrelated, one needs to care about the second order.

z statistics are in ( ); robust standard errors are in [ ]; ***, **, and * indicate significance at 1%, 5%, and 10%, respectively.

Source: Author's own calculation based on data from TURKSTAT.

The results show that the significance and signs of the coefficients did not change in the one-step estimation.