Convergence of Human Capital: Geography and Policy *(Φ)*

Alpay Filiztekin (*), Burhan Can Karahasan (**)

Abstract

This paper seeks to investigate the regional human capital differences in Turkey by questioning the convergence hypothesis during the last two decades. Given that human capital accumulation plays a vital role for understanding the regional inequalities at the very local level, we decide to divert the attention towards the way that human capital level of individuals differ among the 923 districts of Turkey. Initial set of results obtained from district level data for the years of 1990, 2000 and 2010 validate that; central expectations of the neo-classical convergence theory hold for Turkey; districts with relatively lower education levels realize a better human capital development. Moreover we clarify that for the baseline age group of 30-49 the speed of convergence is higher. While these preliminary findings should indicate the fall of regional imbalances for the human capital accumulation, additional results obtained from Exploratory Spatial Data Analysis (ESDA) and Geographically Weighted Regression (GWR) underline that this convergence is not stable (stationary) geographically. Even though the global estimates of the initial human capital underlines an overall convergence, GWR results pin-point that this convergence is not stable among the whole geography of Turkey, which clearly underlines local divergence.

Keywords: convergence, geography, human capital, Turkey
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(*) Sabanci University, Faculty of Arts and Social Sciences, alpayf@sabanciuniv.edu
(**) Okan University, Faculty of Economics and Business Administration, can.karahasan@okan.edu.tr

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1. Introduction

Among different dimensions of regional inequalities human capital development acts as an important factor. The rise of endogenous growth models and the specific role attributed to human capital (education and innovation in specific) finds its place in Lucas (1988) and Romer (1990). In general human capital accumulation seems to act as a necessary condition for a sustained economic growth path for nations (see Barro, 1991; Barro and Sala-i Martin, 1992). From this perspective the way that human capital evolves is a complementary and important question not only for understanding cross country differences but also to evaluate intra-country regional disparities.

While there are different reasons behind the evolution of human capital endowments in different locations, it is more recently the New Economics of Geography (NEG) to search for the possible reasons behind the human capital accumulation (see Redding and Schoot, 2003; Redding and Venables, 2004). Well before this discussion, the usual NEG framework (Fujita et al., 1999) already allows for understanding how agglomeration will work and how economic activity will differ within a given geography; yet none of the models control for the way that factors of productions are dispersed historically. In this sense as an important factor of production, observing the way that human capital development evolves is a valuable contribution. To our understanding this can be best understood by discussing the applicability of the so-called convergence model for human capital development (see Sab and Smith; 2001 and 2002).

From this theoretical discussion, this paper seeks to observe the regional differences of human capital accumulation in Turkey, by focusing on the district level data on education levels of individuals during the last two decades. The central aim is to understand whether there are any signs of convergence from 1990 to 2010. Initially the traditional convergence model as offered by Barro and Sala-i Martin (1992) will be used to understand to what extent regional human capital endowments are converging and/or diverging from each other. While doing this an important expected contribution will be about decomposing the so-called convergence as to understand whether the global convergence estimates obtained from the generalized models are representative at the very local level. That is to say, we aim to finally measure the speed of human capital convergence at each individual district and compare with the global convergence speed obtained in the initial set of analysis. Our hypothesis is that even though there are some possible signs of convergence from the traditional global convergence models, local reflections may be divergent if there are some possible local instability (and/or non-stationarity).

The paper is organized as flows; section 2 aims to give the reader an overall idea about the regional inequality issue in Turkey. Section 3 sketches the theoretical foundations of the convergence theory and its possible application to the human capital development. Section 4 is the exploratory section that offers different ways to question the convergence hypothesis for human capital development. Both exploratory as well as spatial data analysis will be introduced and preliminary results will be evaluated. Within the same section, the benchmark convergence models are also going to be introduced and results will be discussed. Section 5 aims to widen the initial set of results obtained from the traditional convergence model, by discussing the specific place of local stabilities. Finally the paper will conclude.

2. Regional Differences in Turkey

Regional inequalities is one of the, but not the least concerns of Turkey; yet can be discussed on the grounds that numerous reflections are observed at the national level as well. As an economy between western European countries and the eastern Middle Eastern and North African economies, the geographical location of Turkey is crucial. In general the north and south duality observed within the European countries is reflected in the form of west and east duality in Turkey. In this sense it seems that Turkey acts as a geographical as well as economic transition economy within its geography; regions in close proximity to Europe in the western Turkey is well developed with respect to the ones close to the MENA region located on the eastern Turkey. Tekeli (1992) discussed this unique nature of the Turkish economy by focusing on two major factors; with the fall of the Ottoman Empire the major economic systems on the eastern geography of the country (Caucasus and Russia) and the southern geography of the country (Aleppo) collapsed. Moreover the war episode of the early years of the republican period and the loss of human capital and compulsory migration end with an inevitable demographic change between Eastern and Western Turkey. While such an historical discussion may form the background of the east west duality in Turkey, the policy choices of the following era also feed the process. In general though out its development process the conflict between national and regional targets for the policy makers leave Turkey with an inevitable yet difficult question; since the human and physical capital base of Turkey is premature and unevenly distributed, using this base at its highest usage is accepted as a national tool to increase productivity and enhance rapid growth. This unavoidable choice of the policy makers give inspiration on the evolution and development of economic activity centers mostly around the western geography of Turkey, which are already well developed relative to the rest of the Turkey. Such an endogenous process can be discussed on the grounds of Marshalian industrial districts (Marshall, 1920) or von Thünen's (1826) rings of production, yet will fail to explain the social and economic differences of regions.

Within this regional imbalances phenomenon, as discussed by Dogruel (2006) there is no uniform strategy against decreasing the regional inequalities. Early years of the republican period mostly deals with the restructuring of the economy after the heavy war episode and neglected the place of regional imbalances. Even though throughout the planned development period of 1960s regional inequalities are considered and included in the economic plans, implementations are mostly insufficient to close the east west gap. And with the change in the attitude of policy makers after 1980s by trying to increase the integration with the rest of the world, once more regional inequality concerns in neglected. All these developments are subject to influential studies questioning the different dimensions of regional inequalities. Filiztekin (1998, 2012), Dogruel and Dogruel (2003), Karaca (2004), Gezici and Hewings (2004 and 2007) discuss the regional inequality question in Turkey; all underline that even there are some very slow signs of convergence among eastern and western regions, this catch-up struggle is far away from significantly closing the so called gap. Similarly Kılıçaslan and Özatağan (2007) underlined that even there is limited convergence across the provinces in Turkey; a significant portion of this convergence mostly comes from the change in the demographic structure of provinces (mostly population changes).

Among different dimension of regional inequalities, various results and reasons of the regional inequality problem is also discussed. Filiztekin (2009), Elveren (2010), Celebioglu and Dall'erba (2010), Karahasan (2010, 2011), Dogruel and Dogruel (2012), Bilgel and Karahasan (2013), Yeşilyurt and Elhorst (2013) controlled for different social and economic problems of Turkey such as; employment, inflation, wage dispersion, industrial development, educational human capital, security and social development. In general similar to the evolution of income differences they also validate that there are specific reasons for the evolution of positive economies and externalities around the western geography of the country on one hand and the rise of specific negative diseconomies that creates an environment that excludes the development of the eastern regions of the country on the other.

3. Theoretical Framework

The growth and development literature give special emphasis on the way that human capital affects cross country differences in well-beings of nations. Following Romer (1990) endogenous growth literature discuss the different ways that human capital development affects economic growth. Benhabib and Spiegel (1994) adopt the standard Romerian framework by discussing the Nelson and Phelps (1966) idea about the role of human capital to affect and adopt technological development. Barro (1991), Barro and Lee (1993) and Barro (1997) also validate that human capital development of countries have explanatory power to understand the cross country variation of income levels. In general while there are numerous other reasons to understand why there are substantial ongoing differences that feed divergence, studies such as Cohen (1996), Jones (1997), and Pritchett (1997) demonstrate that human capital development may and will have substantial power to understand this inability of convergence.

While the way that human capital development, education in specific affects the economic and productivity growth is a discussion point, the path of the human capital development is also a noteworthy question. If educational human capital acts as such an important factor as to understand the regional imbalances, the way that human capital is dispersed deserves considerable attention. Babini (1991) and O'Neill (1995) demonstrated sizeable human capital convergence among different set of countries, yet have contradictory results about the impact of this convergence on cross country differences. More recently Sab and Smith (2001 and 2002) focus on the development of human capital by implementing some state of the art methodologies offered by the growth literature. Sab and Smith (2001 and 2002) apply the traditional neo-classical income convergence model to the human capital development phenomenon.[1] Results reveal substantial convergence among human capital development for a cross section of countries.

From such a framework one can replicate the discussion towards a different understanding regarding the human capital endowments of locations to converge to each other. While the possible link between the existence of human capital and income convergence is a discussion; understanding whether there are any signs of regional human convergence deserves a separate analysis. Following Sab and Smith (2001 and 2002) we adopt a similar unconditional human capital convergence model as a departure point. Equation 1 is constructed from the traditional

[1] See Barro (1991) and Barro and Sala-i Martin (1992) for a brief discussion of the convergence theory.

convergence equation that aims to link the average growth of human capital of the regions with the initial human capital development. $(1-e^{-\beta T})/T$ tests the existence of convergence; a negative value for the coefficient signals the convergence.

(1) $$\frac{1}{T}\log\left(\frac{y_{i,T}}{y_{i,0}}\right) = a + \left[(1-e^{-\beta T})/T\right]\log\left(y_{i,0}\right) + u_{i0,T}$$

From equation 1 two additional information can be gathered. First the beta that signals the speed of the convergence can be computed. Second of all the half-life of convergence can be computed; that is the time necessary to close the gap between the initial human capital levels with the steady state human capital levels by half, denoted by t. This can be computed from: $e^{-\beta t}$=0.5.

4. Spatial Concentration and Regional Convergence Analysis

Before focusing on the way that the traditional convergence model works in Turkey, some preliminary statistical data analysis will be informative. The human capital data that will be used within the study comes from Population Census Data Base for the years 1990 and 2000; from Address Based Population Registration System Results for the year 2010 both of which provided by Turkish Statistics Office (TURKSTAT). Educational human capital development is controlled by using three different variables: individuals with minimum high school education, minimum university education and average years of schooling. Initial set of analysis is carried out for individuals over 6 years of ages. For all years data is collected at district level. Since the number of districts changes from year to year in Turkey related adjustments are done (aggregation and disaggregation) and the whole analysis is carried out at 923 cross sections.

As to understand the dispersion of human capital initially a number of statistical and spatial analysis are carried out. Equation 2 and 3 are the sigma convergence, which is basically standard deviation obtained from the sample variance and the coefficient of variation, which is mean corrected standard deviation. Results reported in table 1 underlines that even though for sigma convergence measure there is sign of increasing regional inequalities, results reported for the coefficient of variation pin-points that there are substantial decreases in regional inequalities in favor of convergence.

(2) $$\sigma_i^2 = \frac{1}{N}\sum_{i=1}^{N}(HK_i - \mu_i)^2$$

(3) $$CV_i = \frac{\sigma_i}{\mu_i}$$

>>>Insert Table 1 here<<<

Even these first set of analysis yield preliminary information about the path of regional inequalities, observing whether spatial links works during these two decades is also vital. Spatial autocorrelation which can be an issue in the data set under concern will signal if there is any room to discuss the impact of geography on the accumulation of human capital. Two different statistics are preferred; Moran's *I* in equation 4 and Geary's C in equation 5. While Moran measure calculates the spatial autocorrelation by observing the deviation of each observation from the mean (z), Geary's C prefers to focus on the deviation of the each observation from the other pairs of observations. In any case, the geographical interaction is controlled by the weight matrix (W). Throughout the research a contiguity weight matrix is preferred that assigns the value of 1 if two locations are adjacent and 0 otherwise. n is the number of cross sections and s is the summation of the all elements of the weight matrix. Results of the both test are reported in table 2; regardless of the test chosen there is significant positive and continuously rising spatial autocorrelation for human capital development between 1990 and 2010.

(4) $$I_i = \frac{n}{s}\frac{\sum_i \sum_j w_{ij} z_i z_j}{\sum z_i^2}$$

(5) $$C = \frac{(n-1)(\sum_i \sum_j w_{ij}(x_i - x_j)}{2(\sum_i \sum_j w_{ij}(x_i - x_j)^2)}$$

>>>Insert Table 2 here<<<

While the initial set of statistical analysis gives an overall idea about the regional dispersion and spatial concentration of human capital development in Turkey, additional analysis to analytically investigate convergence hypothesis is a necessity. Within this study the way that human capital accumulates and differs will be investigated by following a two-step approach. First the traditional convergence model summarized in the previous section is estimated by using Ordinary Least

Squares (OLS) model with no spatial effects; next the same convergence model is estimated by including the impact of spatial links. Spatial Autoregressive (SAR) models and Spatial Error Model (SEM) are used by assuming spatial interactions over the dependent variable and over the omitted variables respectively. In any case the initial set of convergence analysis will be absolute convergence analysis; that is to say without controlling for the regional heterogeneities.

Equation 6 is the OLS models to be estimated where G(HK) represents the growth of human capital development whereas HK(0) represents the initial human capital development level of districts. In case a significant and negative Ω coefficient is reported, this will signal room for convergence of human capital development.

(6) $$G(HK_i) = \alpha + \Omega HK_{i,0} + \varepsilon_i$$

Results reported in table 3 underlines the significant convergence for each of the human capital variables under concern. In general individuals over 6 years of age with at least university education seems to have the highest convergence with respect to individuals over high school education as well as the average years of schooling in the same age cohorts. In addition to that results reported in table 3 signals that speed of convergence is highest between 1990-2000 with respect to 2000-2010 and 1990-2010 time intervals. As explained in the previous section, the half-life of convergence is computed as to see how long it would take for a district to close the gap with its initial human capital development and its steady state human capital development. Results reported in tables 3 indicate that the longest time necessary to close the gap by half is for the sub period of 2000-2010. While it would take around 30 and 20 years to close the half of the gap in the individual groups with minimum high school and university education respectively between 1990 and 2000, for the period of 2000 to 2010 same measures are computed to be more than at least 50 years. In addition to that results for the average years of schooling for districts indicate a very slow speed of convergence underlining a time period over 50 years to close half of the gap with the steady state level of human capital.

>>>Insert Table 3 here<<<

Even though the first set of OLS analysis give some insight about the convergence question, these models fail to control for the possible effect of spatial dependence in the data. As discussed in table

2, all human capital variables under concern are spatially dependent. Moreover the residuals obtained from the OLS estimations all suffer from residual spatial autocorrelation (see Moran's *I* test results for residuals of the OLS estimates in table 3). This can result in significant biases in the OLS estimates and moreover we will fail to control for the impact spatial links in non-spatial econometric models (see Anselin, 2000). To control for the spatial autocorrelation two additional models are constructed as given in equations 7 and 8. Equation 7 is the SAR model that assumes that spatial dependence works over the district level human capital growth; whereas equation 8 is the SEM model accepts that it is the common shocks (omitted variables of the model) that are correlated across space. Results of the spatial econometric models are given in tables 4 and 5.

(7) $$G(HK_i) = \alpha + \Omega HK_{i,0} + \rho WG(HK_i) + \varepsilon_i$$

(8) $$G(HK_i) = \alpha + \Omega HK_{i,0} + \lambda Wu + \varepsilon_i$$

>>>Insert Table 4 and 5 here<<<

First of all; each estimated model manages to control for the remaining spatial dependence in the residuals (see the Likelihood Test Results in Tables 4 and 5). Moreover in each model under concern the spatial dependence variable (spatial lag of the human capital growth in SAR models and the spatial lag of the error terms in SEM models) is statistically significant and correctly signed in line with the expectations. In general once more results remark that human capital convergence is persistent in nearly all models other than the ones that discuss the path of the minimum high school education convergence and average years of schooling between 2000 and 2010. Although we detect significant signs of convergence for average years of schooling in the OLS estimates; SAR and SEM results for the 2000-2010 period is not in line with the overall results obtained so far. Yet for the whole time interval 1990-2010 results of the spatial econometric models are consistent with the OLS results. Moreover once the speed of convergence is tried to be observed by computing the half-life of convergence measure; results remark that the highest speed is once more detected among individuals with at least university education. District level average years of schooling is still very slowly closing the gap (over 50 years to cover at least half of the gap), yet for individuals with at least high school and university education it would take around 50 and 41 years to close half of the gap during the 1990-2010 period. These comments are based on the SEM estimates, which all signal faster convergence with respect to the non-spatial OLS estimates and SAR estimates.[2]

While the first set of results obtained from OLS, SAR and SEM models are crucial, they fail to control for the possible differences within different age groups; rather question the convergence of human capital in a broader context. To deepen our understanding about the existence as well as the speed of convergence; additional analysis for the age group of 30-49 are carried out. By doing so we expect to focus on the most active age group of the population, which in practice and theory could be more representative than the population over 6 years of age including the dependent age groups. Results for the 30-49 age group for OLS, SAR and SEM specifications are reported in tables 6, 7 and 8.

>>>Insert Table 6, 7 and 8 here<<<

Among each human capital variable, we detect once more that even though there are signs of convergence for each variable, for the district level average years of schooling it seems to be more that optimistic to talk about a reasonable convergence path. In each specification average years of schooling for the individuals between 30-49 ages seems to be converging to steady state at least half way in a period of time more than 50 years. Similar to the evaluations above for this specific age group, we detect to highest convergence for the individuals with minimum university education. Results of the SEM models pin point that for individuals with minimum high school and university education it would take more than 50 years and 32 years to close half of the gap between 1990 and 2010. These results signal that for this specific age group speed of convergence is higher than the whole population over 6 years of age.

5. Local Instabilities: Geographically Weighted Regression Approach

While the first set of analysis yield valuable information about the path of the convergence in Turkey at district level; up to this point analyses neglect an important issue that could be a matter of fact in spatially dependent models. Table 2 already summarizes the spatial autocorrelation test

[2] One possible way to compare OLS, SAR and SEM is over observing the capability of each model to control for the spatial dependence. Results reported in the related tables underline that OLS models fail to control for the spatial residual dependence; whereas SAR and SEM models manage to cope with this issue. In addition to that once the information criterions for all models are compared, results reveal that AIC and SIC are minimized in SEM specification, that give us the highest convergence speed among all models estimated for population over 6 years of education.

results; all underlining the positive significant spatial dependence. Based on this concern as well as the insufficiency of the OLS estimates to control for the spatial dependence, additional SAR and SEM models are already estimated. However in none of these analysis and estimates, the spatial non-stationarity (and/or instability) issue is ever controlled for. In general what can be observed in a global model (OLS, SAR, SEM) does not necessary be reflected at the local level. Anselin (1995 and 1996) discussed this issue and underlined that it seems to be a necessity to decompose and observe the global spatial autocorrelation to search for the possible existence of local instabilities (Exploratory Spatial Data Analysis -ESDA-). That is to say, even though we detect a significant positive spatial autocorrelation, if we do not observe its spatial variability we will fail to understand two specific issues. First the possible outliers that behaves in opposite direction with respect to the global results. Second of all it seems to be impossible to understand the magnitude of the clusters unless its local realizations are observed. Anselin (1995) offered the Local Indicator of Spatial Association (LISA) as a way to understand the significance as well as the magnitude of the local units. LISA measure is summarized in equation 9.

(9) $$LISA = (x_i - \overline{x}) \sum_j w_{ij}(x_j - \overline{x})$$

Based on the concern of local instabilities, for each of the variable under concern LISA calculations are done and figured out accordingly. Figure 1 and 2 give the results obtained from two different age groups for the three years under concern: 1990, 2000, 2010. In general based on the significant local realizations of the global spatial autocorrelation, it seems to be reasonable to underline the existence and persistence of regional imbalances among the last two decades. The persistent and significant cluster of provinces with relatively very low levels of human capital development around the eastern geography signals some possible negative economies that discourage the evolution of a sound environment for human capital accumulation as well as various social and economic issues. Note that results obtained for the year 2010 for both age groups also validate our concerns about the ability of convergence to close the so called gap between eastern and western Turkey.

>>>Insert Figures 1 and 2 here<<<

Even the LISA analysis are very preliminary local data analysis, still they underline that we have to approach to the convergence results obtained from the global models with caution. Based on these findings a second crucial question comes from the possibility of the spatial varying relationship within the model. What is meant by the spatial varying relationship is discussed by Brundsdon et al. (1996, 1999); that is it could be possible to obtain a spatially varying parameter estimates from a model that may give divergent local parameter estimates with respect to a global models that gives only a general and unique parameter estimate for the model. The offered approach is Geographically Weighted Regression (GWR). Equation 10 summarizes the GWR model where u and v are the related coordinates to be used to figure out the variability of each parameter estimated within the model.

$$(10) \quad G(HK_i) = \alpha(u_i, v_i) + \Omega(u_i, v_i)HK_{i,0} + \varepsilon_i$$

Such estimation may be vital from an important point for the ongoing study. Even though we already detect significant convergence results from global models; that is in line with the neo-classical expectations, we are suspicious about the speed and the success of this convergence. Not only the half-life of convergence calculations but also the LISA computations signal that still the eastern districts of Turkey suffer from relatively low levels of human capital development. Table 9 and 10 gives a comparison of the global and local models.[3]

>>>Insert Table 9 and 10 here<<<

Results reported in table 9 and 10 allow us to decompose the global convergence results but also to distinguish the regional imbalances among the whole population (+6 population) with the active population (30-49 age population). In general result remark that there are remarkable differences regarding the convergence finding among the 923 districts of Turkey. The gap between the maximum and minimum values of the district level initial human capital coefficient is observed to be higher for the population over 6 years of age. Within the population over 6 years of age, highest variation is detected for the individuals with minimum university education. Moreover for individuals with minimum university education and average years of schooling there are initial signs of divergence in some given locations. Once we move to the active population base of Turkey, we come to realize that variation of the convergence coefficient diminishes, yet existence of local divergence picture in especially higher levels of education persists.

[3] Note that just the initial human capital coefficients are reported for simplicity. Full model estimates for OLS, SAR an SEM are given in related tables (see tables 3 to 8). Full results for the GWR models are available from the authors up on request.

These GWR results are preliminary yet remarking. Figure 3 and 4 gives us the way that convergence of districts spatially varies for two different age groups: +6 population and 30-49 age population. Based on the results obtained from the GWR models, district level convergence is decomposed into two major groups. Above the mean convergence, we detect the districts that realizes above average convergence (Extreme and slow convergence). On the contrary below the mean convergence we report districts that behave in opposite direction with respect to the global estimates (Extreme and slow divergence). Overall for the total population over 6 years of age, results remark that for individual with minimum high school education overall for the 1990-2010 period eastern and south eastern regions seems to be converging while the western geography seems to be already at its steady state. Here interesting finding belongs to the sub period of 2000-2010, where the convergence speed seems to diminish among the eastern geography. For the individuals with minimum university education, results reveal that district level convergence between 1990-2000 and 2000-2010 is once more contradictory. Finally for this age group, the convergence models works quite different at the very local level, with a more random dispersion regarding the district level convergence.

For the active age group between 30-49 years of age; results pin point once more the spatial varying relationship for the district level convergence. For individual with minimum high school education once more the 2000-2010 period diverges from the findings of 1990-2000 and 1990-2010 periods. For individuals with minimum university education, results are persistent in each sub-period observed; higher convergence among the eastern and south eastern Turkey vs. relatively slower convergence and even divergence among the western Turkey. For the average years of schooling results indicate that the speed of convergence is higher among the eastern geography of Turkey.

>>>Insert Figures 3 and 4 here<<<

Finally the same set of GWR analyses are carried out by controlling for a number of district level properties: share of wage earners, share of agricultural employment, share of manufacturing employment and unemployment rate are used to control for the initial district level social and economical conditions. For simplicity only the GWR maps for these models are reported as in figures 5 and 6. Results validate once more that there are clear signs of imbalances in the convergence of human capital along the whole geography of Turkey.

>>>Insert Figures 5 and 6 here<<<

6. Conclusion

Human capital development and its geographical distribution during the last two decades in Turkey is at the center of the research. The given role of educational human capital development to close the gaps among regions makes this endogenous research question more valuable for a country like Turkey that suffers from persistent regional imbalances throughout the republican period.

While the traditional convergence model can be applied directly to the human capital development questions, our concern mostly departs from the inability of the traditional convergence model to fully capture the local realizations of the convergence. Originating from this point, we first of all estimate a number of benchmark models with and without spatial effects for two different age groups at district level (+6 population and 30-49 population). Results validate that there are considerable convergence among different human capital development measures in Turkey. While it is the average years of schooling that converges at the slowest speed, in general we detect that both individuals with minimum high school education as well as the individuals with minimum university education closes half of the gap with its long run potential around 20 to 40 years depending on the level of education.

While these initial set of analysis give some idea about the way that district level human capital differences behaves, they fail to control for local instabilities. Initial ESDA pin point that local decomposition of the global spatial autocorrelation gives cluster of districts with very low levels of human capital development around the eastern Turkey. Interesting issue is that these clusters mostly sustain their significance and magnitude, which underlines the inability of these districts to catch up the western geography of Turkey. These initial spatial instability analysis make us be more suspicious about the convergence detected in the global models. We further estimate the GWR models to control for the possible local instabilities: results remark remarkable variation of the district level convergence coefficient which once more underlines the danger of focusing on the global convergence parameters estimated so far. Decomposition of the convergence coefficient at the district level underline that depending on the human capital level under concern there are significant local divergence patterns among the geography of Turkey.

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Table 1. Dispersion of Human Capital Development (Age Group: +6 Population)

	Sigma Convergence			Coefficient of Variation		
	1990	**2000**	**2010**	**1990**	**2000**	**2010**
Minimum High School	0.033267	0.046889	0.05502	0.61346	0.445352	0.396662
Minimum University	0.015636	0.025066	0.033424	0.811427	0.737051	0.702018
Years of Schooling	0.964285	1.047194	1.101494	0.261518	0.241935	0.204433

Source: TURKSTAT, Authors' own calculations

Table 2. Spatial Concentration of Human Capital Development (Age Group: +6 Population)

	Moran's I			Geary's C		
	1990	**2000**	**2010**	**1990**	**2000**	**2010**
Minimum High School	0.396*** (0.020)	0.403*** (0.020)	0.427*** (0.019)	0.549*** (0.025)	0.558*** (0.022)	0.557*** (0.022)
Minimum University	0.376*** (0.019)	0.377*** (0.019)	0.355*** (0.019)	0.510*** (0.041)	0.526*** (0.038)	0.595*** (0.035)
Years of Schooling	0.661*** (0.020)	0.594*** (0.020)	0.601*** (0.019)	0.297*** (0.022)	0.359*** (0.023)	0.380*** (0.023)

Notes: ***, ** indicates significance at 1% and 5% respectively, estimations based on 999 permutations

Table 3. Convergence of Human Capital (OLS-Age Group: +6 Population)

	Models I			Models II			Models III		
	1990-2000	**2000-2010**	**1990-2010**	**1990-2000**	**2000-2010**	**1990-2010**	**1990-2000**	**2000-2010**	**1990-2010**
Minimum High School	-0.296*** (0.013)	-0.069*** (0.008)	-0.177*** (0.006)	-	-	-	-	-	-
Minimum University	-	-	-	-0.405*** (0.042)	-0.060** (0.027)	-0.235*** (0.028)	-	-	-
Years of Schooling	-	-	-	-	-	-	-0.004*** (0.0002)	-0.001*** (0.0002)	-0.004*** (0.0001)
Half Life of Convergence (years)	29.624	>50	>50	20.026	>50	38.813	>50	>50	>50
R^2	0.35	0.07	0.41	0.09	0.01	0.08	0.23	0.03	0.48
Obs	923	923	923	923	923	923	923	923	923
AIC	-4690.92	-4925.14	-5864.32	-4574.14	-4525.08	-5348.58	-6323.83	-6076.00	-7448.71
SIC	-4681.26	-4915.49	-5854.66	-4564.48	-4515.43	-5338.92	-6314.17	-6066.35	-7439.06
Moran's I for Residuals	0.273 [0.00]	0.287 [0.00]	0.220 [0.00]	0.194 [0.00]	0.161 [0.00]	0.197 [0.00]	0.256 [0.00]	0.392 [0.00]	0.337 [0.00]

Notes: ***, ** and * represents significance at 1%, 5% and 10% respectively. Standard errors are in ( ) for coefficient estimates. P-values are in brackets. AIC and SIC represent the Akaike and Schwartz Information Criterions respectively. Moran's *I* tests the spatial autocorrelation of the errors with the null hypothesis of spatially random errors.

Table 4. Convergence of Human Capital (SAR-Age Group: +6 Population)

	Models I			Models II			Models III		
	1990-2000	**2000-2010**	**1990-2010**	**1990-2000**	**2000-2010**	**1990-2010**	**1990-2000**	**2000-2010**	**1990-2010**
Minimum High School	-0.243*** (0.013)	0.009 (0.006)	-0.156*** (0.007)	-	-	-	-	-	-
Minimum University	-	-	-	-0.327*** (0.041)	-0.056*** (0.026)	-0.191*** (0.027)	-	-	-
Years of Schooling	-	-	-	-	-	-	-0.003*** (0.0002)	0.0001 (0.0002)	-0.002*** (0.0001)
ρ	0.376*** (0.036)	0.472*** (0.039)	0.273*** (0.036)	0.358*** (0.041)	0.327*** (0.044)	0.363*** (0.041)	0.435*** (0.037)	0.662*** (0.030)	0.457*** (0.032)
Half Life of Convergence (years)	37.343	-	>50	26.255	>50	49.054	>50	-	>50
R^2	0.44	0.17	0.45	0.18	0.08	0.16	0.34	0.37	0.59
Obs	923	923	923	923	923	923	923	923	923
AIC	-4791.9	-4985.51	-5915.49	-4642.16	-4574.62	-5419.74	-6432.74	-6385.5	-7626.96
SIC	-4777.41	-4971.03	-5901	-4627.68	-4560.14	-5405.26	-6418.26	-6371.02	-7612.48
Likelihood Ratio Test (Spatial Dep.)	102.980 [0.00]	130.516 [0.00]	53.168 [0.00]	70.094 [0.00]	51.451 [0.00]	73.264 [0.00]	111.240 [0.00]	311.482 [0.00]	180.597 [0.00]

Notes: ***, ** and * represents significance at 1%, 5% and 10% respectively. Standard errors are in ( ) for coefficient estimates. P-values are in brackets. AIC and SIC represent the Akaike and Schwartz Information Criterions respectively. Likelihood Ratio Test checks for the spatial dependence of the spatial dependence parameter (auto-regressive and error) with the null hypothesis of being equal to zero.

Table 5. Convergence of Human Capital (SEM-Age Group: +6 Population)

	Models I			Models II			Models III		
	1990-2000	**2000-2010**	**1990-2010**	**1990-2000**	**2000-2010**	**1990-2010**	**1990-2000**	**2000-2010**	**1990-2010**
Minimum High School	-0.291*** (0.014)	0.013* (0.007)	-0.181*** (0.007)	-	-	-	-	-	-
Minimum University	-	-	-	-0.388*** (0.046)	-0.063** (0.029)	-0.225*** (0.030)	-	-	-
Years of Schooling	-	-	-	-	-	-	-0.004*** (0.0003)	0.001*** (0.0003)	-0.003*** (0.0001)
λ	0.503*** (0.038)	0.482*** (0.039)	0.434*** (0.041)	0.394*** (0.042)	0.330*** (0.044)	0.393*** (0.042)	0.492*** (0.038)	0.697*** (0.028)	0.589*** (0.034)
Half Life of Convergence (years)	30.233	-	>50	21.175	>50	40.791	>50	-	>50
R^2	0.48	0.18	0.48	0.19	0.08	0.17	0.36	0.39	0.62
Obs	923	923	923	923	923	923	923	923	923
AIC	-4832.65	-4989.14	-5959.86	-4649.38	-4576.62	-5424.77	-6451.97	-6403.03	-7661.51
SIC	-4823	-4979.48	-5950.21	-4639.72	-4566.97	-5415.11	-6442.31	-6393.37	-7651.85
Likelihood Ratio Test (Spatial Dep.)	141.735 [0.00]	132.139 [0.00]	95.544 [0.00]	75.314 [0.00]	51.454 [0.00]	76.290 [0.00]	128.470 [0.00]	327.005 [0.00]	213.145 [0.00]

Notes: ***, ** and * represents significance at 1%, 5% and 10% respectively. Standard errors are in ( ) for coefficient estimates. P-values are in brackets. AIC and SIC represent the Akaike and Schwartz Information Criterions respectively. Likelihood Ratio Test checks for the spatial dependence of the spatial dependence parameter (auto-regressive and error) with the null hypothesis of being equal to zero.

Table 6. Convergence of Human Capital (OLS-Age Group: 30 -49 Age Population)

	Models I			Models II			Models III		
	1990-2000	2000-2010	1990-2010	1990-2000	2000-2010	1990-2010	1990-2000	2000-2010	1990-2010
Minimum High School	-0.189*** (0.009)	-0.144*** (0.006)	-0.168*** (0.005)	-	-	-	-	-	-
Minimum University	-	-	-	-0.271*** (0.026)	-0.315*** (0.020)	-0.282*** (0.015)	-	-	-
Years of Schooling	-	-	-	-	-	-	-0.005*** (0.0002)	-0.005*** (0.0002)	-0.005*** (0.0001)
Half Life of Convergence (years)	49.632	>50	>50	32.894	27.481	31.384	>50	>50	>50
R^2	0.30	0.37	0.31	0.10	0.20	0.27	0.41	0.47	0.66
Obs	923	923	923	923	923	923	923	923	923
AIC	-4491.42	-5010.94	-4506.32	-4088.89	-4180.16	-5103.08	-6370.6	-6578.69	-7444.04
SIC	-4481.77	-5001.29	-4491.84	-4079.23	-4170.5	-5093.42	-6360.94	-6569.04	-7434.39
Moran's I for Residuals	0.126 [0.00]	0.155 [0.00]	0.120 [0.00]	0.112 [0.00]	0.082 [0.00]	0.101 [0.00]	0.169 [0.00]	0.128 [0.00]	0.197 [0.00]

Notes: ***, ** and * represents significance at 1%, 5% and 10% respectively. Standard errors are in ( ) for coefficient estimates. P-values are in brackets. AIC and SIC represent the Akaike and Schwartz Information Criterions respectively. Moran's *I* tests the spatial autocorrelation of the errors with the null hypothesis of spatially random errors.

Table 7. Convergence of Human Capital (SAR-Age Group: 30 -49 Age Population)

	Models I			Models II			Models III		
	1990-2000	**2000-2010**	**1990-2010**	**1990-2000**	**2000-2010**	**1990-2010**	**1990-2000**	**2000-2010**	**1990-2010**
Minimum High School	-0.182*** (0.009)	-0.138*** (0.006)	-0.164*** (0.005)	-	-	-	-	-	-
Minimum University	-	-	-	-0.266*** (0.026)	-0.289*** (0.021)	-0.266*** (0.015)	-	-	-
Years of Schooling	-	-	-	-	-	-	-0.005*** (0.0002)	-0.004*** (0.0002)	-0.004*** (0.0001)
ρ	0.185*** (0.042)	0.189*** (0.040)	0.093*** (0.037)	0.210*** (0.046)	0.216*** (0.044)	0.194*** (0.042)	0.154*** (0.040)	0.227*** (0.037)	0.200*** (0.030)
Half Life of Convergence (years)	>50	>50	>50	33.621	30.483	33.621	>50	>50	>50
R^2	0.31	0.39	0.51	0.13	0.22	0.29	0.42	0.50	0.68
Obs	923	923	923	923	923	923	923	923	923
AIC	-4506.32	-5028	-5535.34	-4104.93	-4199.09	-5119.9	-6383.51	-6612.03	-7483.98
SIC	-4491.84	-5013.52	-5520.86	-4090.45	-4184.61	-5105.41	-6369.03	-6597.55	-7469.5
Likelihood Ratio Test (Spatial Dep.)	16.896 [0.00]	19.056 [0.00]	5.481 [0.01]	18.0447 [0.00]	20.937 [0.00]	18.817 [0.00]	14.908 [0.00]	35.339 [0.00]	41.937 [0.00]

Notes: ***, ** and * represents significance at 1%, 5% and 10% respectively. Standard errors are in ( ) for coefficient estimates. P-values are in brackets. AIC and SIC represent the Akaike and Schwartz Information Criterions respectively. Likelihood Ratio Test checks for the spatial dependence of the spatial dependence parameter (auto-regressive and error) with the null hypothesis of being equal to zero.

Table 8. Convergence of Human Capital (SEM-Age Group: 30 -49 Age Population)

	Models I			Models II			Models III		
	1990-2000	**2000-2010**	**1990-2010**	**1990-2000**	**2000-2010**	**1990-2010**	**1990-2000**	**2000-2010**	**1990-2010**
Minimum High School	-0.197*** (0.010)	-0.152*** (0.006)	-0.172*** (0.005)	-	-	-	-		-
Minimum University	-	-	-	-0.299*** (0.027)	-0.306*** (0.021)	-0.281*** (0.015)	-		-
Years of Schooling	-	-	-	-	-	-	-0.005*** (0.0002)	-0.005*** (0.0002)	-0.005*** (0.0001)
λ	0.300*** (0.045)	0.352*** (0.044)	0.279*** (0.046)	0.275*** (0.046)	0.208*** (0.048)	0.237*** (0.047)	0.363*** (0.043)	0.287*** (0.046)	0.402*** (0.042)
Half Life of Convergence (years)	47.389	>50	>50	29.268	28.463	31.517	>50	>50	>50
R^2	0.33	0.42	0.53	0.14	0.22	0.29	0.62	0.50	0.70
Obs	923	923	923	923	923	923	923	923	923
AIC	-4527.99	-5064.47	-5564.21	-4118.55	-4196.4	-5125.82	-6430.71	-6613.96	-7522.6
SIC	-4518.34	-5054.82	-5554.55	-4108.89	-4186.75	-5116.16	-6421.06	-6604.3	-7512.95
Likelihood Ratio Test (Spatial Dep.)	36.572 [0.00]	53.530 [0.00]	32.348 [0.00]	29.656 [0.00]	16.245 [0.00]	22.738 [0.00]	60.113 [0.00]	35.265 [0.00]	78.560 [0.00]

Notes: ***, ** and * represents significance at 1%, 5% and 10% respectively. Standard errors are in ( ) for coefficient estimates. P-values are in brackets. AIC and SIC represent the Akaike and Schwartz Information Criterions respectively. Likelihood Ratio Test checks for the spatial dependence of the spatial dependence parameter (auto-regressive and error) with the null hypothesis of being equal to zero.

Table 9. Convergence of Human Capital (Initial HK: Global vs Local Models, Age Group: +6 Population)

	Global Models			GWR Results				
	OLS	SAR	SEM	Minimum	Lower Quartile	Median	Upper Quartile	Maximum
Minimum High School								
1990-2000	-0.296*** (0.013)	-0.243*** (0.013)	-0.291*** (0.014)	-1.166	-0.423	-0.342	-0.238	0.02
2000-2010	-0.069*** (0.008)	0.009 (0.006)	0.013* (0.007)	-0.215	-0.121	-0.09	-0.06	0.08
1990-2010	-0.177*** (0.006)	-0.156*** (0.007)	-0.181*** (0.007)	-0.427	-0.254	-0.206	-0.159	0.05
Minimum University								
1990-2000	-0.405*** (0.042)	-0.327*** (0.041)	-0.388*** (0.046)	-4.845	-0.911	-0.589	-0.267	1.642
2000-2010	-0.060** (0.027)	-0.056** (0.026)	-0.063** (0.029)	-0.752	-0.138	0.026	0.320	1.200
1990-2010	-0.235*** (0.028)	-0.191*** (0.027)	-0.225*** (0.030)	-2.498	-0.404	-0.218	0.019	3.088
Years of Schooling								
1990-2000	-0.004*** (0.0002)	-0.003*** (0.0002)	-0.004*** (0.0003)	-0.015	-0.007	-0.005	-0.003	0.008
2000-2010	-0.001*** (0.0002)	0.0001 (0.0002)	0.001*** (0.0003)	-0.003	0.0004	0.001	0.002	0.0136
1990-2010	-0.004*** (0.0001)	-0.002*** (0.0001)	-0.003*** (0.0001)	-0.0135	-0.004	-0.003	-0.002	0.013

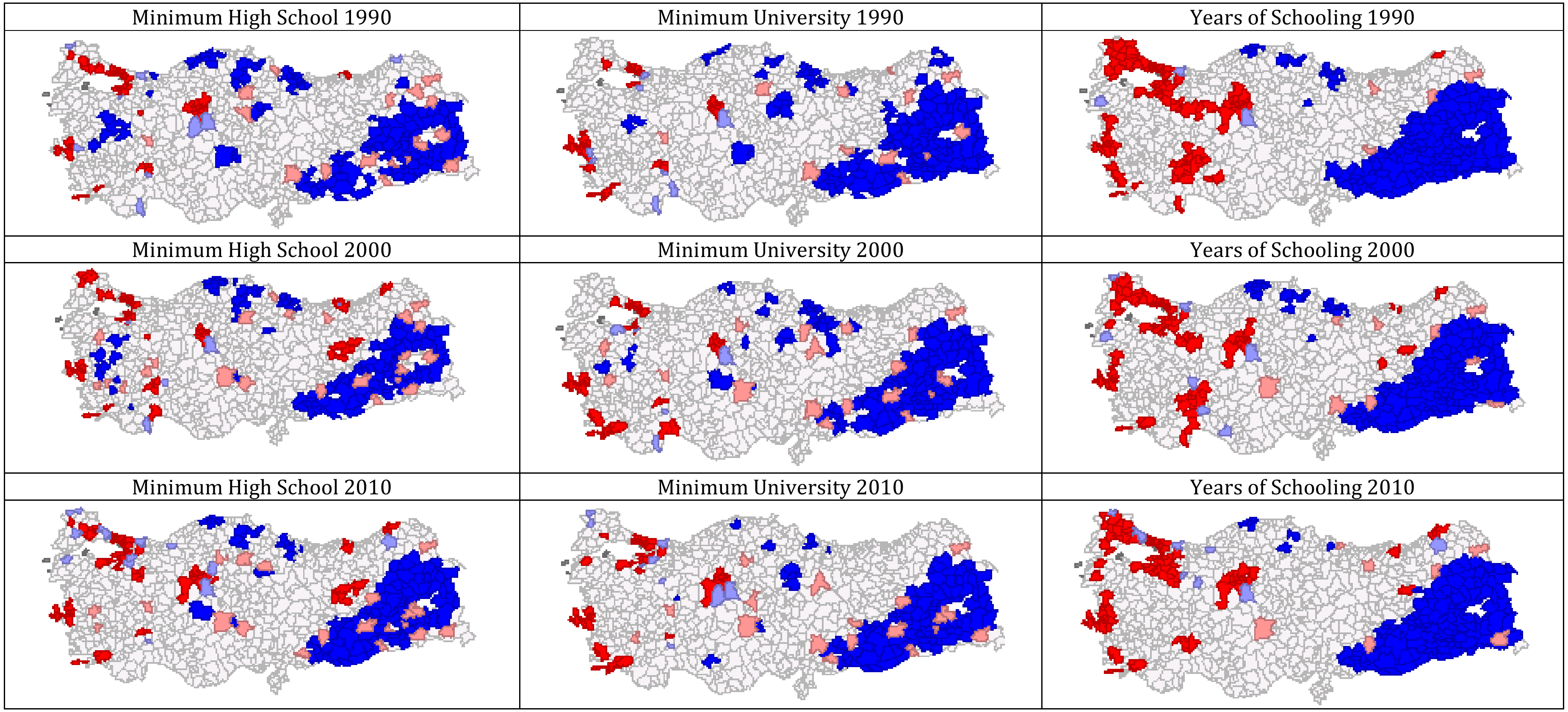
Notes: ***, ** and * represents significance at 1%, 5% and 10% respectively. Standard errors are in ( ) for coefficient estimates.

Table 10. Convergence of Human Capital (Initial HK: Global vs Local Models, Age Group: 30 -49 Age Population)

	Global Models			GWR Results				
	OLS	**SAR**	**SEM**	**Minimum**	**Lower Quartile**	**Median**	**Upper Quartile**	**Maximum**
Minimum High School								
1990-2000	-0.189*** (0.009)	-0.182*** (0.009)	-0.197*** (0.010)	-0.669	-0.223	-0.192	-0.159	-0.08
2000-2010	-0.144*** (0.006)	-0.138*** (0.006)	-0.152*** (0.006)	-0.660	-0.200	-0.150	-0.113	0.09
1990-2010	-0.168*** (0.005)	-0.164*** (0.005)	-0.172*** (0.005)	-1.154	-0.226	-0.176	-0.131	0.123
Minimum University								
1990-2000	-0.271*** (0.026)	-0.266*** (0.026)	-0.299*** (0.027)	-1.765	-0.591	-0.407	-0.228	0.050
2000-2010	-0.315*** (0.020)	-0.289*** (0.021)	-0.306*** (0.021)	-1.599	-0.545	-0.328	-0.180	0.405
1990-2010	-0.282*** (0.015)	-0.266*** (0.015)	-0.281*** (0.015)	-1.223	-0.489	-0.316	-0.196	0.347
Years of Schooling								
1990-2000	-0.005*** (0.0002)	-0.005*** (0.0002)	-0.005*** (0.0002)	-0.015	-0.006	-0.005	-0.004	-0.001
2000-2010	-0.005*** (0.0002)	-0.004*** (0.0002)	-0.005*** (0.0002)	-0.014	-0.005	-0.004	-0.003	0.001
1990-2010	-0.005*** (0.0001)	-0.004*** (0.0001)	-0.005*** (0.0001)	-0.019	-0.005	-0.004	-0.003	0.005

Notes: ***, ** and * represents significance at 1%, 5% and 10% respectively. Standard errors are in ( ) for coefficient estimates.

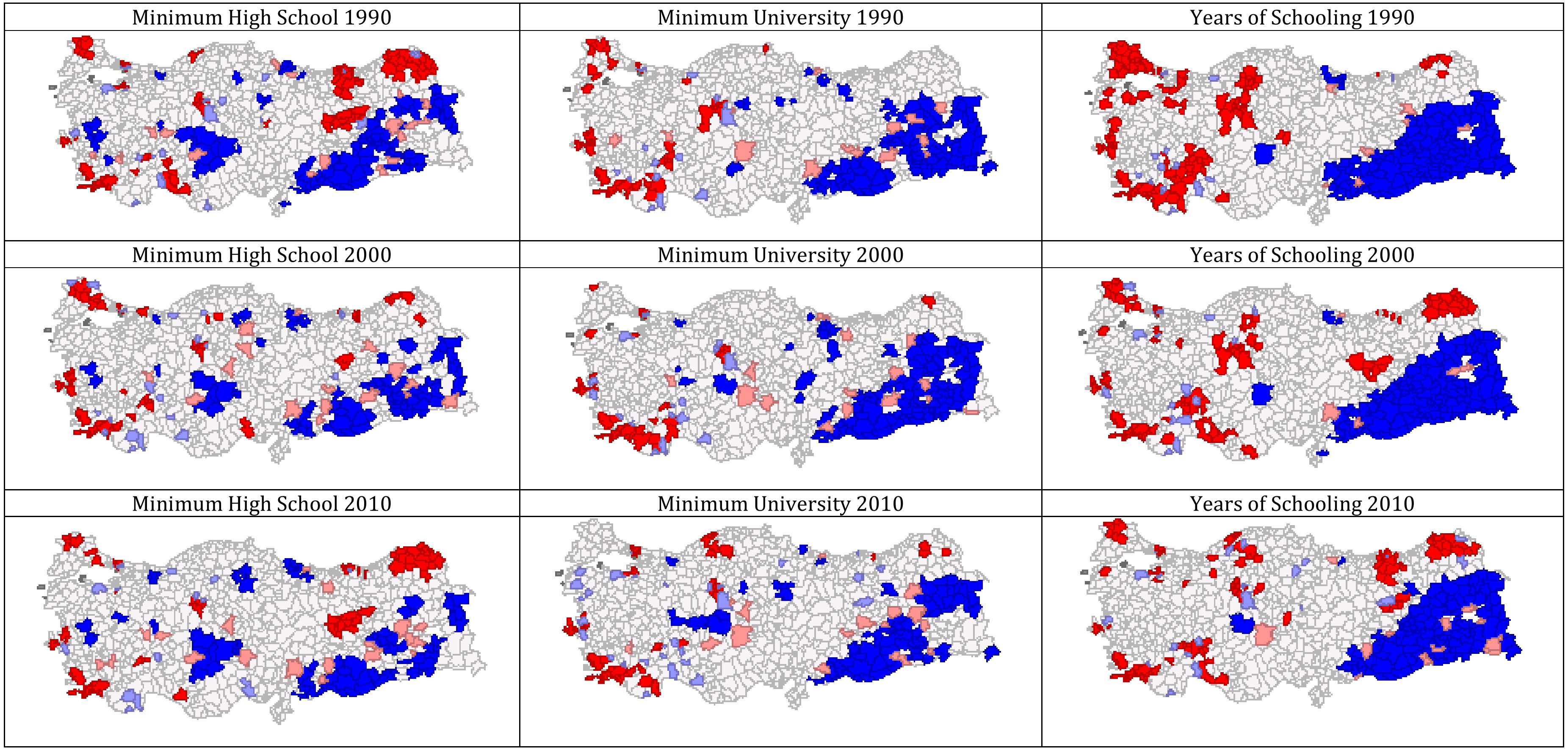
Figure 1. LISA Maps for Human Capital Development (+6 Age Population)



Source: TURKSTAT, Authors' own calculations
Notes: Based on 999 permutations, significance at 5% level

- High-High Clusters
- Low-Low Clusters
- Low Outliers
- High Outliers
- Non-Significant Local Units

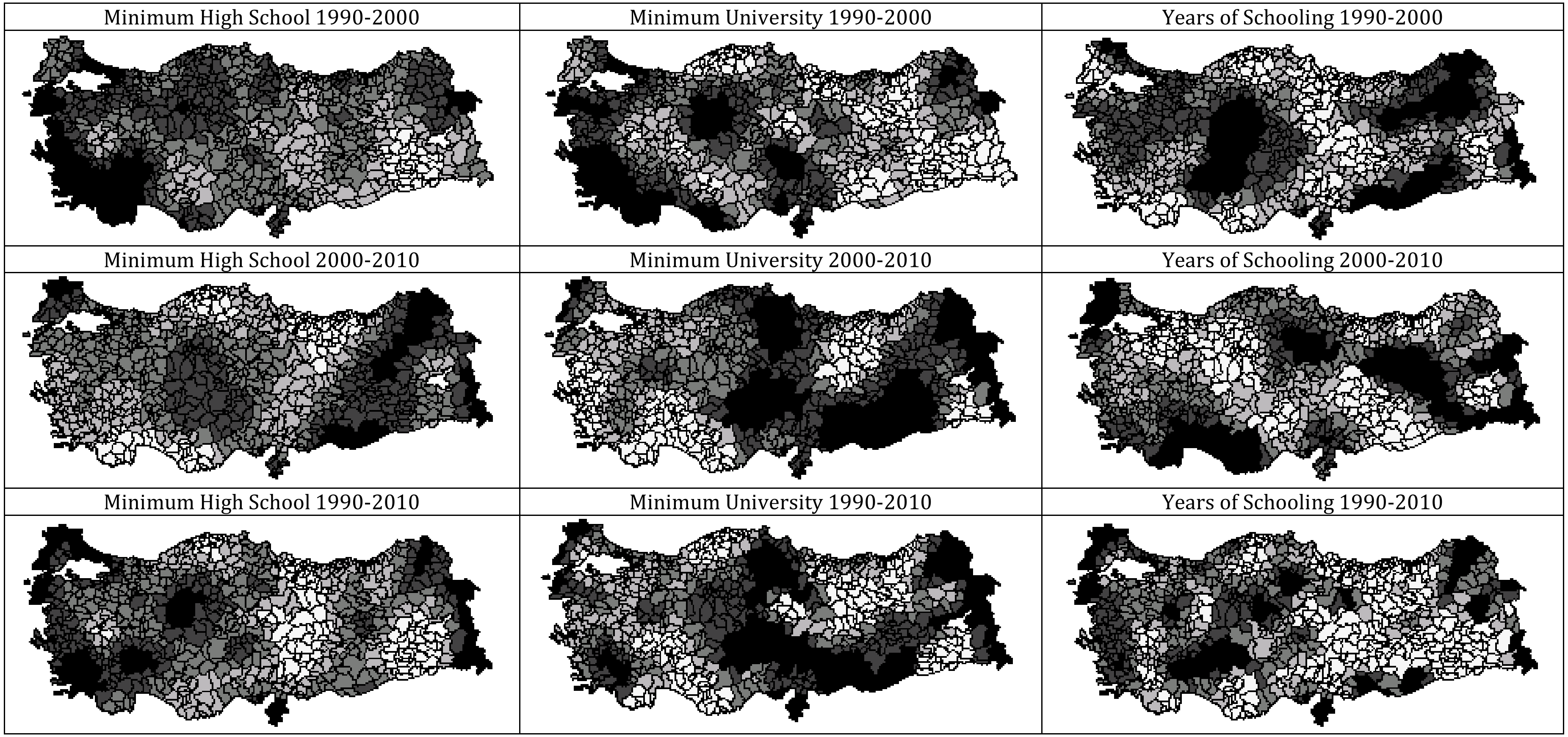
Figure 2. LISA Maps for Human Capital Development (30-49 Age Population)



Source: TURKSTAT, Authors' own calculations
Notes: Based on 999 permutations, significance at 5% level

High-High Clusters
Low-Low Clusters
Low Outliers
High Outliers
Non-Significant Local Units

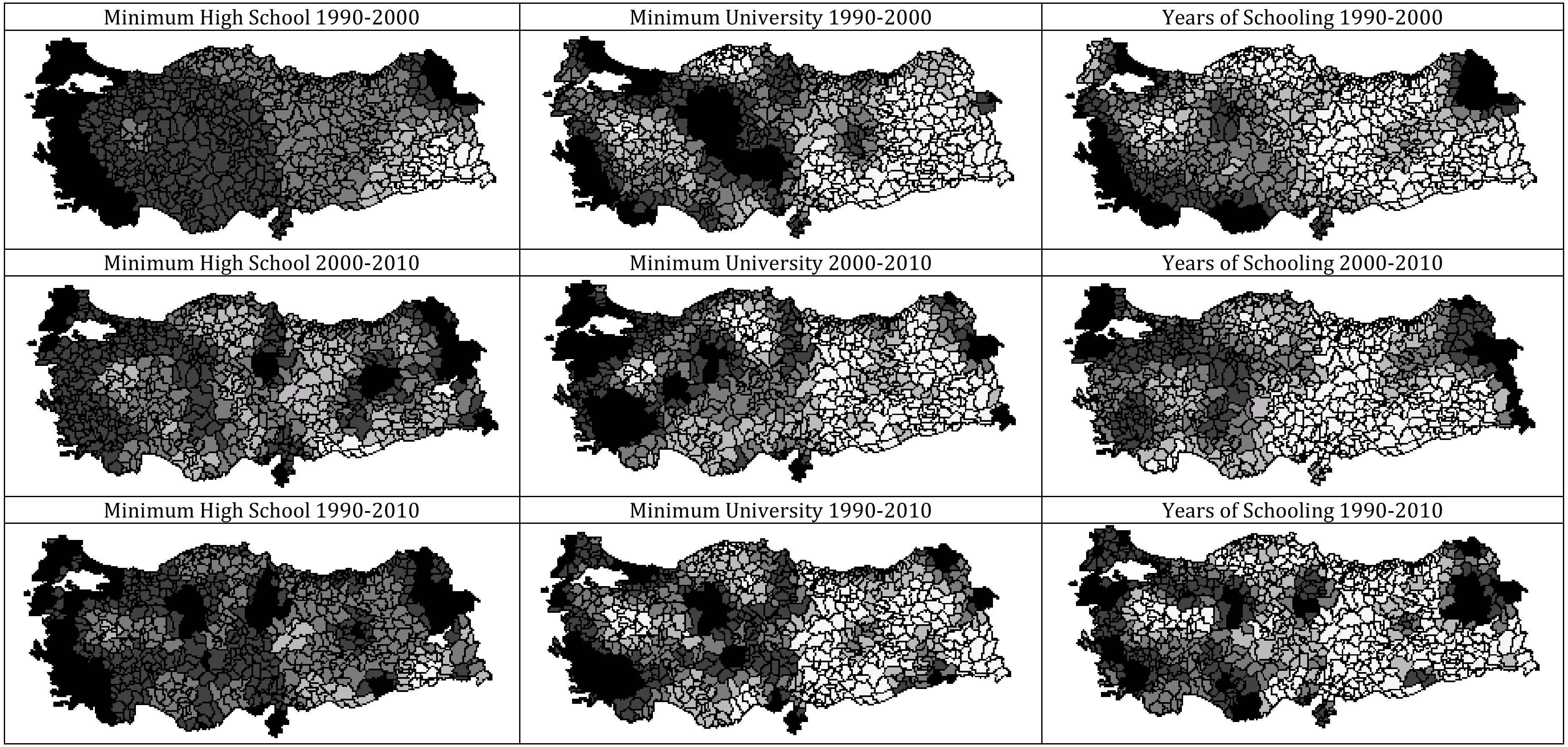
Figure 3. GWR Results (+6 Population)



Source: TURKSTAT, Authors’ own calculations

Extreme Convergence
Slow Convergence
Mean Convergence
Slow Divergence
Extreme Divergence

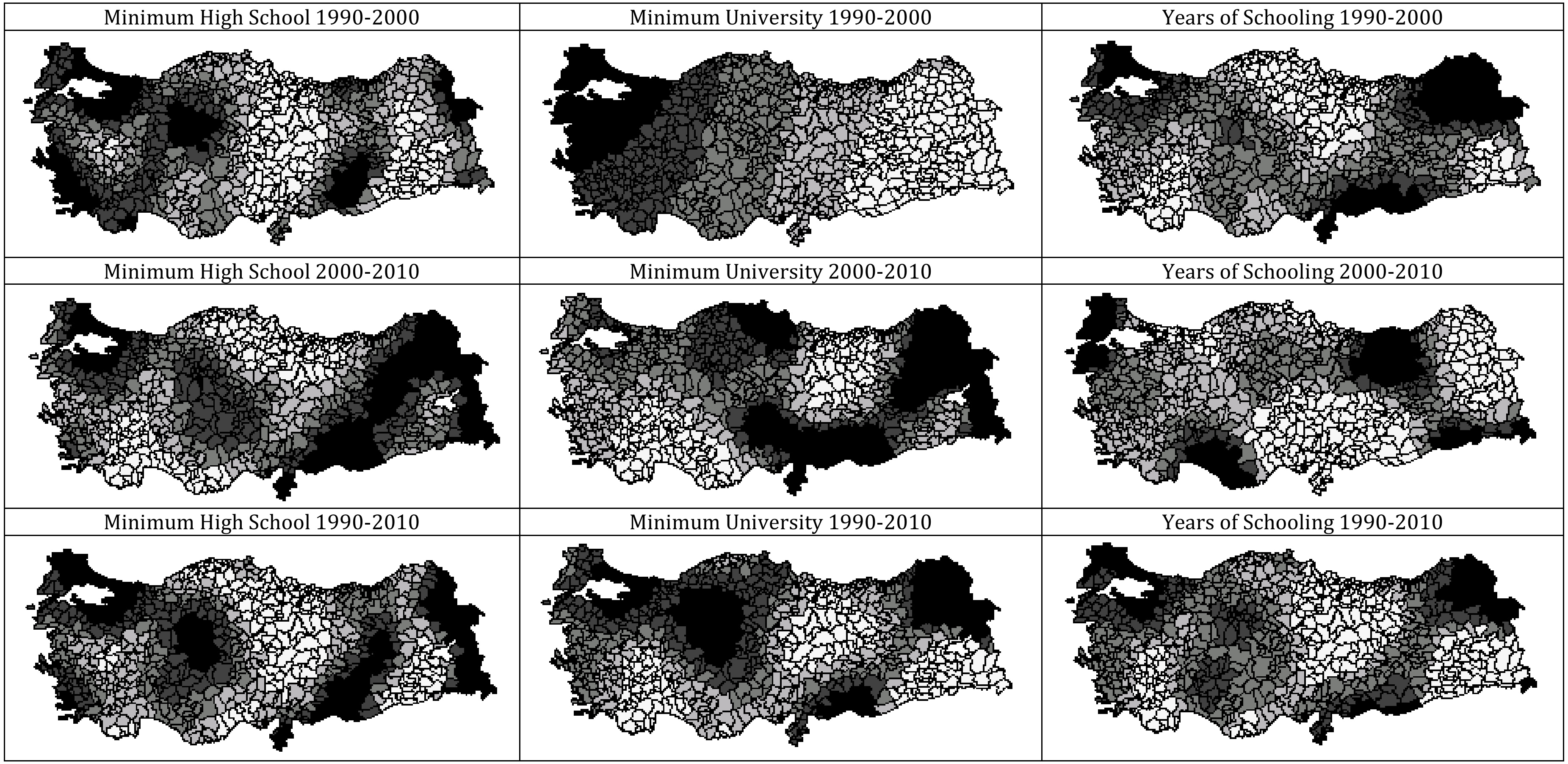
Figure 4. GWR Results (30-49 Age Population)



Source: TURKSTAT, Authors' own calculations

Extreme Convergence
Slow Convergence
Mean Convergence
Slow Divergence
Extreme Divergence

Figure 5. GWR Results (Conditional Models: +6 Population)



Source: TURKSTAT, Authors' own calculations

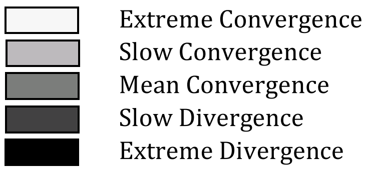
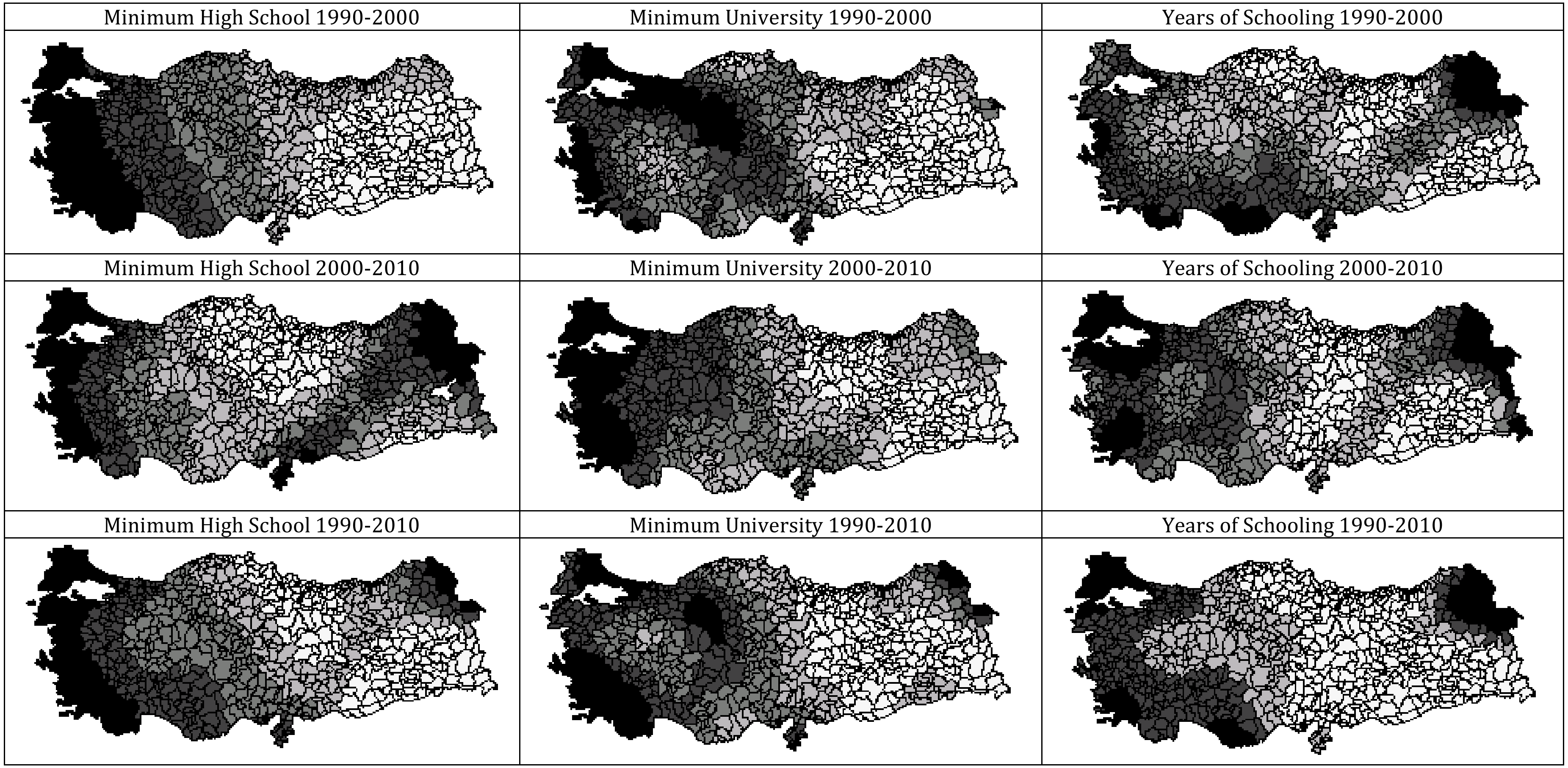


Figure 6. GWR Results (Conditional Models: 30-49 Age Population)



Source: TURKSTAT, Authors' own calculations

Extreme Convergence
Slow Convergence
Mean Convergence
Slow Divergence
Extreme Divergence