THE EFFECTS OF PUBLIC CAPITAL ON REGIONAL CONVERGENCE IN TURKEY

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Working Paper No: 07 / 01

January 2007
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ABSTRACT

In recent years there have been many studies that explore the impact of public capital formation on economic growth at regional level, because public capital might give rise to reducing regional disparities across regions. Regarding Turkey, investigating the effects of public capital on economic convergence at the regional level gains importance since significant regional disparities exist between the regions.

This study attempts to explore the dynamic effects of public capital on output per capita in terms of convergence in the Turkish regions. A conditional convergence model based on per capita GDP and public capital is estimated using the panel data set of Turkish regions at NUTS 1 level for the time period 1980-2001. The spatial effects are also investigated.

The results show that there exists conditional convergence. The results also reveal that in some of the models public capital has a positive and significant effect on output per capita. However, in the models with spatial effects the public capital does not have a significant effect on regional convergence.

Keywords
Regional development, public capital, convergence, Turkish regions, spatial effects

JEL classification: H54, R11

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1 We would like to thank the Scientific and Technological Research Council of Turkey (TUBITAK) for the financial support they gave for this project under grant SOBAG-104K112.

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1. Introduction

Since the seminal work of Aschauer (1989a and 1989b), investigating the effects of public capital on economic growth has gained importance. Recently, there has been considerable number of empirical studies attempting to investigate the impact of public capital on regional economic performance in many countries (see, for example, Munell and Cook, 1990; Holtz-Eakin, 1994; Garcia-Mila et al., 1996; Pereira and Flores, 1999; Pereira and Roca-Sagales, 2001; Zugasti et al., 2001; Karadağ et al., 2004). In general, the results of these studies show that public capital has a positive effect on regional economic performance in many countries (see, for example Pereira and Flores, 1999; Zugasti et al., 2001; Karadağ et al., 2004). On the other hand, some of these studies found no clear evidence of positive effects of public capital on private sector output at the regional level for some countries (See, for example, Holtz-Eakin, 1994; Garcia-Mila et al., 1996).

Investigating the impact of public capital on private sector output has gained attention both at the national and regional levels, because studies in this area show that the stock of public capital plays an important role in the regional economic growth (See Lall and Yilmaz, 2001; Kim and Lee, 2002; Pereira and Roca-Sagales, 2003). Efficient and appropriate provision of public capital has a very important role in improving access to markets and in reducing unit cost of production. Also, since public capital can be complementary for private capital, it attracts private investment. Furthermore, recent literature in this area has pointed out that public capital has a spillover effects (see Lall and Yilmaz, 2001; Deliktaş et al., 2003; Pereira and Roca-Sagales, 2003). Thus, spatial distribution of public capital might well have important implications for changing regional disparities and for the convergence process.

Hence, in the light of above arguments, we can say that public capital stock can affect regional economic convergence. However, there appears to be only a few studies concerning the effects of public capital on regional economic convergence. Lall and Yilmaz (2001) examined the impact of public in the convergence process in the United States and found out that public capital did not affect the speed of regional convergence. Shioji (2001) studied the dynamic effects of public capital on output per capita by using panel data for American and Japanese regions. The results of the study show that the infrastructure component of public capital has a significantly positive effect on long run regional output per capita in both
countries. Apart from its direct effect on economic growth, the study also shows that public capital has an indirect effect on regional economic growth by stimulating private investments.

In Turkey, recently there has been a growing attention to regional convergence. Without any attempt to give an exhaustive account of all of these existing studies related to regional convergence in Turkey, we give the results of some of these studies. Filiztekin (1997) carried out a study to find out whether there is convergence across the Turkish provinces for the time period 1975-1995. The results of this study indicate that there is only conditional convergence in output per capita. On the other hand, Tansel and Gungor (1998) have obtained contradictory results supporting convergence across the provinces for the same period in terms of labor productivity. They concluded that there exists absolute and conditional convergence across the provinces. Berber et al. (2000) carried out a research to find out whether there is convergence between the regions by using $\beta$ and $\sigma$ convergence approaches by using the data for 1975-1997 time period. They concluded that there is no convergence among the regions for the time period under consideration. Furthermore, Karaca (2004) investigated whether there is $\beta$ and $\sigma$ convergence among the provinces for the time period 1975-200 and found no convergence among the provinces. Gezici and Hewings (2004) examined regional convergence and concluded that there is no evidence for convergence across both provinces and functional regions in Turkey for the time period 1980 and 1997. Yıldırım (2005) has examined the role of regional policy in economic convergence for Turkey for the time period 1990-2001 at the provincial level. She has obtained results showing $\beta$ convergence at the national level. Erlat (2005) investigated convergence at the provincial and regional level by using time series approach for the 1975-2001 period and found out that there is no strong evidence of convergence in Turkey.

Hence one might say that the studies related to convergence suggest that there is no clear evidence of convergence both at provincial and regional level in Turkey (See also Erlat 2005). Although there are several studies analysing convergence in Turkey, there seems to be shortage of studies related to which factors may affect regional convergence as far as Turkey is concerned. To our best knowledge, only Yıldırım (2005) has examined the role of government investment expenditures and investment incentive policies in regional economic convergence. The results of the study indicate that regional policy variables have no affect on convergence.
As mentioned before, public capital may have an affect on regional convergence. In this context, studying the impact of public capital on regional convergence gains importance, since there are regional disparities between the regions in Turkey. Also, as Turkey is a candidate member of the European Union (EU), the problem of convergence in income is of particular interest, given that it is directly linked to one of the Unions fundamental guiding principles. However, there appears to be no study related to the impact of public capital on regional convergence as far as Turkey is concerned.

Therefore, the main aim of this study is to investigate the impact of public capital on regional convergence at NUTS I level by using dynamic panel data for the time period 1980-2001. The rest of the paper is organised as follows. Section 2 gives some information about convergence. Section 3 explains the basic economic characteristics of the regions and gives some basic data at NUTS I level. The theoretical model is explained in section 4. Section 5 explains the empirical methods used for the aim of the study, while section 6 gives detailed information about data employed in the study. Section 7 gives the estimates of the study. The final section underscores the main findings of the study and gives some policy recommendations.

2. Convergence

In general, convergence can be defined as two or more countries or regions becoming similar in the development of certain economic variables such as, income per capita, growth rate, and total factor productivity over time. The mechanism behind convergence is that poor countries or regions grow faster than rich ones and catch-up rich countries or regions.

Convergence can be interpreted in different ways. Islam (2003) indicates some of them as: convergence within an economy versus convergence across economies; convergence in terms of growth rate versus convergence in terms of income level; absolute convergence versus. conditional convergence; $\beta$-convergence versus $\sigma$-convergence; global convergence versus local convergence, and income convergence versus total factor productivity convergence.
**Beta (β) convergence:** tendency of being similar of economic units in respect to growth rate, income level or low-income countries grow faster than high-income countries are called β-convergence. It refers negative correlation between initial per capita income level and subsequent growth rates; therefore, the β coefficient has a negative sign in regression analysis. The key feature of β-convergence is diminishing marginal returns of capital. The marginal productivity of capital is high in capital-poor countries while it is low in capital-rich countries. Therefore, poorer countries will grow faster than richer countries with similar saving rates (Islam, 2003).

Ramsey (1928), Solow (1956), Cass (1965), and Koopmans (1965) indicated that in neo-classical growth models there exists an inverse relationship between initial production level or per capita income and per capita income growth due to diminishing marginal returns of capital. In addition, if economies are similar in terms of preferences and technologies, poor economies grow faster than the rich ones. On the other hand, if technologies are different, capital mobility toward rich countries may create divergence across countries in terms of per capita income and capital stock. Movement of physical and human capital from poor countries to rich countries compensates effect of diminishing returns of capital (Baro and Sala-i Martin, 1992).

Quah (1993a) and Friedman (1994) emphasized that a negative sign of β does not necessarily imply a reduction in dispersion of income or growth rate across countries. Thus, it should be considered as the country specific dynamics of dispersion of income level or growth rate across countries. In this context, Myrdal (1957) and Hirschman (1958) developed cumulative causation theory assumed that increasing returns to scale, agglomeration, and specialization would cause divergence of regional development. According to the theory, the
factors of production move in the same direction towards high-returned regions in a free market economy. It also argues that the initial high returns to investment would attract more investment and regional advantages would be reinforced by returns to scale and agglomeration economies (Karadağ et al., 2004).

In the literature, there exists large of empirical studies that test for $\beta$-convergence. These studies mainly estimated convergence across economies. Abromovitz (1986) and Maddison (1987) found $\beta$-convergence among some industrialized countries. Baro and Sala-i Martin (1992), Mankiw, Roomer and Weil (1992) estimated $\beta$-convergence for per capita income levels of poorer and richer countries using cross-sectional data.

**Sigma ($\sigma$) convergence:** analysis standard deviations of the cross-sectional dispersion of income level or growth rates of economic units. If standard deviation of income levels reduces over time, it means $\sigma$-convergence. In sigma convergence, the coefficient of variation can also be used instead of standard deviation. The reduction in the coefficient of variation over time shows convergence and the increase in the coefficient of variation over time refers divergence (Karaca, 2004).

Although sigma convergence is consistent with the neo classical theory, it does not give information on the structural parameters of growth models. However, beta convergence gives information on the structural parameters of growth models.

**Conditional and unconditional convergence:** unconditional or absolute convergence argues that economies are similar in terms of institutional structure, saving rates, and technology. Therefore, all economies converge to a common per-capita rate or steady state
equilibrium level. In contrast, the conditional convergence depends on the structural characteristics of each economy and equilibrium differs by the economy, and each economy approaches its own but unique equilibrium. Therefore, the country-specific appropriate variables should be included on the right side of the growth-initial level regression (Islam, 2003).

In this context, Lall and Yılmaz (2001) state that public capital accumulation and human capital formation are also important factors contributing to variations in regional economic structures, therefore, these kind of factors explaining regional differences should be considered in conditional convergence approach.

3. Main Economic Indicators in NUTS-1 level in Turkey

In spite of the 1994 crisis, Turkish economy performed well between 1980-2000. It grew at an 4.5 % on average in this period (see www.dpt.gov.tr). However, there are still big disparities between the regions and provinces in Turkey. Especially, as there is an excessive agglomeration of people and industry in the western part, the disparities are high between eastern part and western part of Turkey. Eastern part of Turkey is much less developed than the western part. Hence, relatively more developed regions in the western part enhance inequalities between the regions and provinces (see also Karadağ et al., 2004). Thus, the existence of the substantial regional disparities between west and east has become very important issue in regional economic policies. Although, Turkey has followed economic policies to reduce regional inequalities since 1970s, there has not been much success in this issue.
The following table gives some basic economic data regarding the regions at NUTS I level.

**Table 1: Basic Data for Turkish Regions at NUTS I Level**

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TR1 Istanbul</td>
<td>10018.7</td>
<td>14.78</td>
<td>2644.2</td>
<td>150</td>
<td>22.18</td>
<td>11.52</td>
</tr>
<tr>
<td>TR2 Western Marmara</td>
<td>2896.0</td>
<td>4.27</td>
<td>1998.2</td>
<td>113</td>
<td>4.84</td>
<td>4.23</td>
</tr>
<tr>
<td>TR3 Aegean</td>
<td>8938.8</td>
<td>13.18</td>
<td>2037.6</td>
<td>116</td>
<td>15.25</td>
<td>18.31</td>
</tr>
<tr>
<td>TR4 Eastern Marmara</td>
<td>5741.2</td>
<td>8.47</td>
<td>2573.9</td>
<td>146</td>
<td>12.37</td>
<td>8.86</td>
</tr>
<tr>
<td>TR5 Western Anatolia</td>
<td>6443.2</td>
<td>9.50</td>
<td>2062.1</td>
<td>117</td>
<td>11.12</td>
<td>12.35</td>
</tr>
<tr>
<td>TR6 Mediterranean</td>
<td>8706.0</td>
<td>12.84</td>
<td>1653.1</td>
<td>94</td>
<td>12.05</td>
<td>12.04</td>
</tr>
<tr>
<td>TR7 Central Anatolia</td>
<td>4189.3</td>
<td>6.18</td>
<td>1251.5</td>
<td>71</td>
<td>4.39</td>
<td>6.07</td>
</tr>
<tr>
<td>TR8 Western Black Sea</td>
<td>4895.7</td>
<td>7.22</td>
<td>1373.5</td>
<td>78</td>
<td>5.63</td>
<td>7.06</td>
</tr>
<tr>
<td>TR9 Eastern Black Sea</td>
<td>3131.5</td>
<td>4.62</td>
<td>1108.1</td>
<td>63</td>
<td>2.90</td>
<td>2.87</td>
</tr>
<tr>
<td>TRA North Eastern Anatolia</td>
<td>2507.7</td>
<td>3.70</td>
<td>744.3</td>
<td>42</td>
<td>1.56</td>
<td>2.83</td>
</tr>
<tr>
<td>TRB Middle Eastern Anatolia</td>
<td>3727.0</td>
<td>5.50</td>
<td>844.1</td>
<td>48</td>
<td>2.63</td>
<td>4.90</td>
</tr>
<tr>
<td>TRC Middle Eastern Anatolia</td>
<td>6608.6</td>
<td>9.75</td>
<td>917.1</td>
<td>52</td>
<td>5.07</td>
<td>8.96</td>
</tr>
<tr>
<td>Turkey</td>
<td>67803.9</td>
<td>100.00</td>
<td>1760.9</td>
<td>100</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

As can be seen from the table, there is a clear existence of regional disparities in population, income distribution, and GDP per capita. The table also shows that public investment expenditures are not used in the right direction to reduce regional inequalities in the country. While GDP per capita in Istanbul is 2644.2 YTL, it is 744.3 in North Eastern Anatolia region. When we take real GDP as the proportion of Turkey’s average, the inequalities between the regions can be seen more clearly. As the table shows, real GDP per capita in the western regions is higher than Turkey’s average. Especially, GDP per capita in North Eastern Anatolia and Middle Eastern Anatolia regions is much below the Turkey’s average (42 and 48 % respectively). Also, the western regions get higher share of GDP compared to eastern regions. For example, while Istanbul has 14.78 % of population, its’ share in total GDP is 22.18 %. On the other hand, the share of North Eastern Anatolia in total population is 3.7 %, whereas its share in total GDP is 1.56 %.

The table also shows that public resources are not used efficiently in order to reduce regional disparities. As the table indicates, the western regions get relatively high amount of public investment. In order to reduce regional disparities, the government should invest more in less developed regions. Compared to the share of population, the less developed regions get relatively small amount of public investment. For example, despite the share of Aegean
region in total population is 13.18%, its share in total public investments on average is 18.31%. On the other hand, North Eastern Anatolia, relatively least developed region, has 3.7% of total population and gets 2.83% of total public investments on average.

Reducing regional disparities between the regions is important in the context of the European Union (EU) membership, given that EU suggests that disparities between the regions in the member countries should be eliminated. In this respect, more public investment should be directed to the less developed regions in order to reduce regional disparities.

4. Theoretical Model
In Barro and Sala-i Martin (1992), and Mankiw, Romer and Weil (1992), conditional convergence is examined through conversion of the theoretical model to an empirically testable form. In both of these works they used Solow model.

Following Mankiw, Romer and Weil (1992), we will derive the theoretical model. We define a Cobb-Douglas production function with constant returns to scale and labor-augmenting technological progress:

\[ Y_t = K_t^\alpha (A_t L_t)^{1-\alpha} \quad 0<\alpha<1, \quad (1) \]

where \( Y \) is output, \( K \) is capital, \( L \) is labor, \( A \) is the level of technology respectively. In Solow model saving rate, population growth, and technological progress are assumed to be exogenously determined. \( A \) and \( L \) are assumed to grow at rates \( g \) and \( n \). It is also assumed that a constant fraction of output \( (s) \) is saved.

Defining \( k \) as stock of capital per effective labour \( k = K / AL \) and \( y \) as output per unit of effective labour \( y = Y / AL \), the dynamic equation for \( k \) is expressed by:

\[ \dot{k}(t) = s \cdot y(t) - (n + g + \delta)k(t) \quad (2) \]

where \( \delta \) is the depreciation rate.
Equation 2 implies that \( k \) converges to its steady states value. By using steady state value of \( k \), steady state per capita income is given by:

\[
\ln \left( \frac{Y(t)}{L(t)} \right) = \ln A(0) + gt + \frac{\alpha}{1 - \alpha} \ln s - \frac{\alpha}{1 - \alpha} \ln(n + g + \delta) \tag{3}
\]

Let \( y^* \) denotes steady state level of income per effective. Approximating around the steady state gives,

\[
\frac{d \ln y}{dt} = \lambda [\ln y^* - \ln y] \tag{4}
\]

By solving the first order differential equation in Equation 4 we get,

\[
\ln y_t = e^{-\lambda \tau} \ln y_{t-1} + (1 - e^{-\lambda \tau}) \ln y^* \tag{5}
\]

where \( \tau \) refers to the time period, and \( \lambda \) to the rate of convergence.

This cross sectional model was extended to the panel case by Islam (1995). Panel data allows for heterogeneity between regions. However, convergence models with cross section data ignore regional heterogeneity and may generate omitted variable problem (See, Islam 1995, and Islam, 2003, for details). Panel version of the Equation 5 can be written as

\[
\ln y_{it} = e^{-\lambda \tau} \ln y_{i,t-1} + (1 - e^{-\lambda \tau}) \ln y^*_{it} + u_{it} \tag{6}
\]

where \( u_{it} \) denotes error term.

According to Solow model countries may reach different steady states. The differences in steady states per capita income between regions depends on differing determinants of steady state income. In other words Solow model predicts that income per capita in a region converges to that regions steady state value (Mankiw, 1992). Hence, it is possible to represent
convergence in Solow model by inclusion of the determinants of steady state. This is named as conditional convergence as explained in section 2.

We extend the model with inclusion of public capital and construct a conditional convergence model. The effect of public capital on steady state per capita income could be represented as:

\[
\ln y^*_i = \delta \ln \text{pubcap}_{i,t-1} + y_i
\]  

(7)

By combining Equation 6 and 7 we reached to the econometric model used in the study as:

\[
\ln y_{it} = \alpha_i + \beta \ln y_{it-1} + \gamma \ln \text{pubcap}_{i,t-1} + u_{it}
\]

(8)

where \( \beta = e^{-\lambda t} \), \( \gamma = (1 - e^{-\lambda t}) \delta \), and \( \alpha_i = (1 - e^{-\lambda t}) \tilde{y}_i \).

5. Empirical Methods
There exist four different methodologies to estimate conditional convergence in the literature (see Islam, 2003, for the details). These methodologies could be classified as: cross section approach, panel approach, time series approach and distribution approach. In this study we apply panel approach because in recent years, there has been an increasing interest in estimation with panel data. Panel data offer researchers the possibility to control for individual heterogeneity, they are in general more informative and contain less collinearity among the variables. Furthermore the use of panel data increases efficiency in the estimation through the use of greater degrees of freedom (see, Baltagi, 2001, Elhorst, 2003).

Also, estimation with dynamic panel data models has been widely discussed in the literature and various estimation methods have been proposed in recent years. Following, Shioji 2001 and Lall and Yilmaz 2001, we use a dynamic model as well in this study. Since there is no consensus on the preferred method, we use different techniques listed below:
1) Pooled regression:
In this model, we regress $y_{it}$, on $y_{it-1}$ and $pubcap_{it-1}$ through *OLS*. This method ignores the possible presence of unobserved regional heterogeneity. In the presence of unobserved heterogeneity across regions this technique estimates $\beta$ with a downward bias. (see, Hsiao, 2003)

2) Least Squares Dummy Variables (LSDV):
In this model, regional dummies are added to the model. Nickell (1981) shows that LSDV estimator for $\beta$ is biased downwards in dynamic panel estimation. Even for $T=30$ the bias may be equal to as much as 20% of the true coefficient and as the time dimension increases this bias diminishes (Judson and Owen 1999).

3) GMM-SYS:
Arellano and Bond (1991) propose a generalized method of moments (GMM) estimator to the following differenced equation

$$\Delta \ln y_{it} = \beta \Delta \ln y_{it-1} + \gamma \ln pubcap_{it-1} + \Delta u_{it}$$

where beginning from $y_{it-2}$ lagged level values of dependent variable is used as instruments.

GMM estimator in differences has been criticized in the literature. Blundell and Bond (1998) found that when true $\beta$ approaches to one, $\beta$ estimator tends to show a downward bias in the dynamic panel. Blundell and Bond (1998) suggest a system GMM estimator. In this method a system of equations is estimated in first differences (Equation 9) and in levels (Equation 8). Lagged first differences are used as instruments for the additional level equations. The consistency of the GMM estimator depends on the nonexistence of the second order autocorrelation. The validity of the instruments can be checked by the Hansen test of over identifying restriction.

4) Spatial Panel Data:
The spatial econometric literature has emphasized that OLS estimation is weak for models including spatial effects. In the existence of spatial error autocorrelation, the OLS estimators for regression coefficients are unbiased and consistent, but inefficient. Erroneously omitting the spatially lagged dependent variable causes OLS estimator to be biased and inconsistent (Anselin,1998). Therefore, Elhorst (2003) proposes maximum likelihood techniques for spatial panel data models.
Firstly, fixed effects model could be extended to include spatially lagged dependent variable as follows:

\[
\ln y_{it} = \alpha_i + \rho W \ln y_{it} + \beta \ln y_{it-1} + \gamma \ln pubcap_{it-1} + u_{it} \tag{10}
\]

where \( W \) denotes spatial weight matrix, \( \rho \) is spatial autoregressive coefficient. This model takes the name of fixed effect spatial lag model (FSLM). In this study we consider binary connectivity matrix. Hence the elements of the weight matrix take the value of 1 if the two regions have a common border and zero otherwise.

Spatial effect can also take part inside the error term:

\[
\ln y_{it} = \alpha_i + \beta \ln y_{it-1} + \gamma \ln pubcap_{it-1} + u_{it} + \epsilon_{it} \tag{11}
\]

\[
u_{it} = \phi W u_{it} + \epsilon_{it}, \quad E(\epsilon_{it}) = 0, \quad Var(\epsilon_{it}) = \sigma^2
\]

where \( W \) denotes again the weight matrix, \( \phi \) is the spatial autocorrelation coefficient. This model is called as fixed effect spatial error model (FSEM).

In the estimation of the fixed effect model in general the intercept term is eliminated through demeaning the variables and then the demeaned equation is estimated through OLS. In spatial panel data models commonly used procedure is estimation of the demeaned equation by maximum likelihood (see, Elhorst, 2003, for details).

6. Data

In this study, per capita real income and public capital stock were used to estimate conditional convergence in NUTS-1 level regions of Turkey. The panel data covers the time period of 1980-2001. The regional per capita income were obtained from two different resources for two different time periods, namely 1980-1986 and 1987-2001. Per capita income for the period 1980-1986 was obtained from Özütün’s (1988) study, and per capita income for the period 1987-2001 was obtained from the State Institute of Statistics (SIS). In order to adjust two different data sets for the whole period, we used the equation (12) given in Filiztekin and Tunali’s (1998) study.
\[ Y_i = \left( \frac{Z_{it}}{Z_t} \right) X_t \]  \hspace{1cm} (12)

where \( Z_{it} \) denotes the income of the \( i^{th} \) province at year \( t \), and \( Z_t \) denotes the national income in year \( t \) for Özütün’s study (1988). \( X_t \) shows the national income at \( t \) from the SIS database. Thus, the income of province \( i \) for the pre-1987 period is obtained using the equation (12).

The second data set used in the study is NUTS-1 level public capital stock for time period 1980-2001. In order to calculate capital stock, we used public investment series for 1963-2001. The investment series for periods 1963-1981 and 1982-2002 were obtained Kutbay’s study (1982) and State Planning Organization, respectively. Public capital stock was calculated through Perpetual Inventory Method (PIM). This method is one of the methods of calculating capital accumulation. The method uses past investment expenditures to calculate capital stock by considering depreciation rates. The PIM is as follows:

\[ K(t) = (1 - \delta)K(t-1) + I(t) \]  \hspace{1cm} (13)

where \( K(t) \) denotes real capital stock at time, \( I(t) \) denotes the real investment series at time \( t \), and \( \delta \) is the depreciation rate. In order to calculate the public capital stock for regions, the benchmark public capital stock is required. Since public capital stock is not available for NUTS-1 level in Turkey, the initial capital stock was estimated by using the following equation:

\[ K(t) = \sum_{j=1}^{L} (1 - \delta)^j I(t - j) \]  \hspace{1cm} (14)

where \( L \) denotes the lifetime of the investments, and the other notations have already been explained in equation (13). The lifetime of investments in calculating capital stock may
change according to countries and sectors of economies. OECD determined the lifetime as 26 years for manufacturing industries (Saygılı, Cihan and Yurtoğlu, 2005). However, Marashoğlu and Tıktık (1991) calculated the sectoral capital stocks for 1968-1988 in Turkey. They determined the lifetime of investment as a 19 years for manufacturing industries of Turkey.

In this study, we determined the lifetime of investments as 17 years to calculate regional public capital stock for time period 1980-2001, because public investment series are available from 1963. Thus, the depreciation rate was calculated as a 5.88% in our study.

7. Estimation
Before we estimate the conditional convergence model we examined $\sigma$-convergence for NUTS 1 regions of Turkey for 1980-2001. Table 2 presents average per capita income and coefficient of variation annually. As the table shows as the per capita income grows through years there is a decline in coefficient of variation.
In order to test the statistical significance of this decline, we regress average per capita income on time trend.

\[
\ln CV = 5.755 - 0.0667T + \varepsilon_t
\]

(50.783) (-7.734)

\[ R^2 = 0.749 \quad F(1,21) = 59.825 \]

\( t \) statistics are in parenthesis.
where CV denotes coefficient variation of per capita income and \( T \) denotes time trend. Negative and significant coefficient of time trend supports the existence of \( \sigma \)-convergence at NUTS 1 regions. In this respect, we also test for the conditional convergence to see the effect of public capital on convergence.

Table 3: Estimation Results

<table>
<thead>
<tr>
<th>Dependent Variable: ( y_{it} )</th>
<th>Pooled</th>
<th>LSDV</th>
<th>GMM-SYS(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
<td>0.114</td>
<td>-1.431</td>
<td>(-1.35)</td>
</tr>
<tr>
<td></td>
<td>(0.98)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( y_{i,t-1} )</td>
<td>0.975***</td>
<td>0.880***</td>
<td>0.851***</td>
</tr>
<tr>
<td></td>
<td>(93.49)</td>
<td>(35.39)</td>
<td>(17.30)</td>
</tr>
<tr>
<td>pubcap(_{i,t-1})</td>
<td>0.007</td>
<td>0.056*</td>
<td>0.154***</td>
</tr>
<tr>
<td></td>
<td>(0.35)</td>
<td>(1.72)</td>
<td>(2.30)</td>
</tr>
<tr>
<td><strong>Convergency rate</strong></td>
<td>0.025</td>
<td>0.128</td>
<td>0.160</td>
</tr>
<tr>
<td>( \lambda )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.982</td>
<td>0.983</td>
<td></td>
</tr>
<tr>
<td>( N )</td>
<td>252</td>
<td>252</td>
<td>252</td>
</tr>
</tbody>
</table>

**Instruments diagnostics**

| Hansen\(^b\)                    | 11.87  |
| AR(1)\(^c\)                     | -2.87***|
| AR(2)                           | -0.71  |

Notes: \( t \) statistics are in parenthesis.
* , ** and *** denotes 10%, 5% and 1% significance level.
a two-step GMM estimator
b Hansen validity of instruments test: under \( H_0 \) of valid instrument distributed \( \chi^2 \).
c AR(1) denotes 1. order AR(2) 2. order autocorrelation tests of residuals: under \( H_0 \) of no autocorrelation distributed \( N(0,1) \).

Table 3 present the results of estimation Equation 8 using different estimators mentioned in Section 5. These techniques do not take the spatial effect into account. The
dependent variable is real income per capita in logarithmic form. Real public capital stock in log form is included to the models as additional explanatory variable. λ convergence rate is also presented in the table. Diagnostic tests related to the GMM are satisfactory.

Pooled regression is a restricted form of LSDV. To test the validity of this restriction F test has been performed. The F statistic was found as 1.68 and significant at 10% level. Hence, we found empirical support related to the validity of unrestricted model (LSDV).

In all of the models the β coefficient of \( y_{it-1} \) was found to be positive and significant implying the existence of conditional convergence. The coefficient of pooled regression implies higher dynamic effect relative to LSDV and GMM-SYS.

The coefficient of pubcap \( _{it-1} \) is positive in all of the models and also significant in LSDV and GMM-SYS. As we compare the convergence rates obtained from the models, the pooled regression has much smaller rate as in Shioji (2001). This result may suggest that the convergence rate of pooled regression may be biased downwards. In the light of these findings we conclude that LSDV and GMM-SYS techniques are more reliable. In these models convergence rates are found to be 0.13 and 0.16 respectively

### Spatial Effects

We extended the fixed effect model through inclusion of spatial effects and conducted estimations through maximum likelihood. Table 4 presents the estimation results related to FSLM and FSEM explained in Section 5.

In the models, with spatial effect, β coefficient was also found to be positive and significant. In the FSLM, the variable \( W.y_{it} \) was computed by taking the average value of per capita income for the contiguous neighbors of a region. The coefficient of \( W.y_{it} \) was found to be positive and significant. In the FSEM spatial autocorrelation number φ is positive and significant. These results suggest that important spatial interactions exist in the models.

---

3 λ convergence rate is calculated as natural logarithm of the estimated β.

4 The test statistic is  

\[
F_{m,n-k} = \frac{(RSS_r - RSS_u)/m}{RSS_u/n - k}
\]

where RSS, and RSS_u stand for restricted and unrestricted residual sum of squares. m, n, and k denotes number of restrictions, number of observations and number of estimated parameters respectively.
In the FSLM and FESM, the sign of $\gamma$ is still positive but insignificant. The convergencly rate are 0.20 and 0.15 respectively. When compared to the previous models the convergency rates are higher in models with spatial effects. The results of the study are in line with the results of the studies that found conditional convergence in Turkey (see, for example, Filiztekin, 1998; Tansel and Güngör, 1998).

Table 4: Estimation Results with Spatial Effect

<table>
<thead>
<tr>
<th></th>
<th>FSLM</th>
<th>FSEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_{it-1}$</td>
<td>0.812***</td>
<td>0.831***</td>
</tr>
<tr>
<td></td>
<td>(18.481)</td>
<td>(25.204)</td>
</tr>
<tr>
<td>Pubcap$_{it-1}$</td>
<td>0.041</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>(1.345)</td>
<td>(0.176)</td>
</tr>
<tr>
<td>$W_iy_{it}$</td>
<td>0.09*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.846)</td>
<td></td>
</tr>
<tr>
<td>$\phi$</td>
<td></td>
<td>0.613***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.000)</td>
</tr>
<tr>
<td>Convergency rate $\lambda$</td>
<td>0.208</td>
<td>0.185</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.985</td>
<td>0.990</td>
</tr>
<tr>
<td>$N$</td>
<td>252</td>
<td>252</td>
</tr>
</tbody>
</table>

Not: $t$ statistics are in parenthesis.

* , ** and *** denotes 10%, 5% and 1% significance level.

8. Conclusion

In this study, we estimated the effects of public capital stock on regional convergence using conditional convergence model based on initial per capita real income and public capital stocks at NUTS-1 level regions in Turkey. Additionally, we estimated spatial effects on conditional convergence. This study is based on panel data of 12 sub-regions for the time period 1980-2001. We used dynamic panel estimation methods for the aim of the study.
The results of the study show that $\sigma$-convergence and conditional convergence exist for the period 1980-2001 at NUTS-1 level. Also, the estimation results of LSDV and GMM-SYS were found to be more reliable in measuring the effects of public capital stock in the regional convergence process. The results of two models indicate that the public capital stocks have a positive effect on per capita income at NUTS-1 level regions. However, when the spatial effect was included to the model, a positive effect of public capital on per capita income lost significance.

The reason why public capital stock has no strong impact on convergence can be explained by not using it to reduce regional disparities. As can be seen in Table 1, the relatively more developed western regions obtained more public investments than relatively less developed regions compared to population distribution. The rate of return of investment is also higher in developed regions due to agglomeration economies (Karadağ et al., 2004). As far as the national economic development policy is considered, this policy can be thought as being reasonable. However, in order to reduce regional economic differences, public investments gain significance to reduce regional disparities as far as Turkey is concerned. Regarding this, more public investment should be made in the relatively less developed regions. Also, public investment policies should be diversified in terms of social investments like education, healthcare, and public administration according to regional needs (Karadağ et al., 2004).
References


www.dpt.gov.tr/ekonomikvesosyalgostergeler
