THE SPILLOVER EFFECTS OF PUBLIC CAPITAL FORMATION ON THE MANUFACTURING INDUSTRY IN THE TURKISH GEOGRAPHICAL REGIONS

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Working Paper No: 07 / 02

February 2007

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The Spillover Effects of Public Capital Formation on the Manufacturing Industry in the Turkish Geographical Regions*

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ABSTRACT

This paper investigates the spillover effects of public capital formation on the Turkish private manufacturing industry at the regional level over the period 1980-2000. The aggregate effects of public capital cannot be captured entirely from the direct effects of public capital installed in the region itself. Therefore, we estimate vector autoregression (VAR) models for the seven geographical regions of Turkey by including capital formation installed outside of the region. The results show that public capital affects private sector performance positively in all regions apart from Central Anatolia. Positive spillover effects of public capital can be seen in some regions, like Marmara.

Key words: Regional development, public capital, spillover effects, vector autoregression, Turkish manufacturing industry.

JEL classification: C32, L60, R00

* A previous version of this study was presented at the METU/ERC International Conference in Economics VII, 6-9 September 2003, Ankara, Turkey.
1. Introduction

Since the seminal work of Aschauer (1989a and 1989b), the role of public capital in the development process has attracted much interest. Recently, investigating the impact of public capital on private output has been an issue of considerable interest in the regional development literature. Regarding this, there have been several empirical studies investigating the effects of public capital on private sector output in many countries (see, for example, Munell and Cook, 1990; Pereira and Flores, 1999; Zugasti et al. 2001, Karadag et al. 2004). The results of these studies generally point to the positive effects of public capital on private sector performance. However, some studies found no clear evidence of positive linkage between public capital formation and private sector output at the regional level for some countries (see, for instance, Holtz–Eakin 1994; Garcia-Milà et al. 1996; Pereira and Roca-Sagalés, 2001). The diversity of empirical results of the literature on the regional effects of public capital on private sector performance could, at least partially, be explained by the fact that they ignore spillover effects of public capital across regions. In fact, spillover effects should not be ignored when investigating the effects of public capital on private sector performance at the regional level, since public capital installed in one region may give benefit to the other regions. In spite of the fact that spillover effects of public capital are important at the regional level, there appear only a few studies in this area (see, for example, Holtz-Eakin and Schwartz, 1995; Boarnet, 1998; Pereira and Roca-Sagalés, 2003). However, the results of these empirical studies are inconclusive. For example, Boarnet (1998) finds negative spillover effects of public infrastructure, while Pereira and Roca-Sagalés (2003) find positive spillover
effects of public capital for almost all regions. On the other hand Holtz-Eakin and Schwartz suggest that there is no quantitatively important spillover effect of public capital between the states in the USA.

Despite the fact that interest in the effect of public capital formation on national and regional economies has generated a voluminous literature in other countries, there appears to be a lack of studies dealing with the impact of public capital in Turkey. To the authors’ best knowledge, there appears only one study (Karadag et al. 2004) that deals with the impact of public capital formation on private sector performance at the regional level. As far as we are concerned, the present study is the first attempt to investigate the spillover effects of the public capital on the Turkish private manufacturing industries at the regional level. Studying the spillover effects of public capital between the regions in Turkey gains importance, since there exists significant differences between regions of Turkey. Investigation of the spillover effects of public capital at the regional level will also be helpful in formulating economic policies for the reduction of regional inequalities.

Therefore, the main aim of this paper is to analyze the regional effects of public capital formation and the possible existence of spillover effects on the manufacturing industries in the seven regions in Turkey for the period 1980-2000. It is believed that public capital can motivate private sector performance directly as an additional input in private production and indirectly by having an impact on private production through dynamic feedback effects among the relevant variables, such as private inputs, capital, labor, and output (see also Wang, 2002). Therefore, following Pereira and Flores, 1999;

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1 In this study as the aggregate data are not available at the regional level, we are restricted to the manufacturing industry.
and Pereira and Roca-Sagalés, 2003, we use Vector Autoregression (VAR) analysis by employing data over the period 1980-2000 for the aim of the study. The spillover effects of public capital formation at the regional level are based on the impulse response functions related with the estimated VAR models.

The remainder of this paper is organised as follows. Section two provides information about the data set used in the study. Section three is about the methodology used in the study and the estimation of the VAR models. Evaluation of the results are summarised and discussed in section four. The paper concludes with a summary analysis of the findings in section five.

2. Data

We employed annual data on output, employment, and capital related to private manufacturing industry and public capital data at regional levels for the aim of the study. The data set covers the time period of 1980 to 2000 for the seven regions.

The data for the private manufacturing industry of each region were obtained from several issues of Annual Manufacturing Industry Statistics published by State Institute of Statistics (SIS). Manufacturing industry wholesale price index was obtained from several issues of Monthly Bulletin of Wholesale Price Index, published by SIS. Investment deflators for public investments were taken from Main Economic Indicators published by State Planning Organization (SPO). The public investment series were obtained from Kutbay (1982) and SPO (see http://www.dpt.gov.tr/kamuyat) for the entire period.
The private output is calculated by subtracting the value of the stock at the beginning of a year from the total sales plus the value of the stock at the end of that year, and was measured in constant prices by taking 1994 as the base year. Inputs used in our model are labor and capital at regional levels. The labor input is measured as total number of workers in production. The private capital input is measured as the total horsepower\(^2\). The public capital input was calculated through perpetual inventory method\(^3\). In order to calculate the public capital input at the regional level over the period 1980-2000, the real public investment series was obtained through deflating the nominal investment series by using the public investment deflator. All of the variables are used in the logarithmic forms in the following sections.

The following figure shows the geographical division of seven regions in Turkey.

![Geographical Regions of Turkey](image)

**Figure 1. Geographical Regions of Turkey**

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\(^2\) Total horsepower of installed equipment can also be used as a proxy for capital. (see, Taymaz and Saatçı, 1997).

\(^3\) See, for example, Önder et al. (2003) for more details on the method.
Table 1 presents share of regional manufacturing value added and regional public capital on average.

**Table 1: Average Percentage Share of Regional Manufacturing Value Added and Regional Public Capital (1980-2000)**

<table>
<thead>
<tr>
<th>Regions</th>
<th>Regional value added (% of Turkey)</th>
<th>Regional public capital (% of Turkey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aegean</td>
<td>15.73</td>
<td>19.37</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>8.16</td>
<td>15.56</td>
</tr>
<tr>
<td>Marmara</td>
<td>59.60</td>
<td>20.24</td>
</tr>
<tr>
<td>Central Anatolia</td>
<td>9.38</td>
<td>19.24</td>
</tr>
<tr>
<td>Black Sea</td>
<td>4.65</td>
<td>10.53</td>
</tr>
<tr>
<td>South Eastern Anatolia</td>
<td>1.89</td>
<td>8.01</td>
</tr>
<tr>
<td>Eastern Anatolia</td>
<td>0.59</td>
<td>7.05</td>
</tr>
</tbody>
</table>

As the table indicates Marmara region has almost 60%, while Eastern Anatolia has only 0.59% of the total value added created in Turkish manufacturing industry. Marmara region also attracts the highest percentage public capital (20.24%), whereas Eastern Anatolia obtains the lowest percentage (7.05%).

3. Methodology and Estimation

In this study, following Pereira and Flores (1999) we employed a multivariate dynamic approach, namely VAR modeling, to estimate the spillover effects of public capital on regional level. This approach allows us to consider dynamic feedback relations between private sector variables and public capital as well as among private sector variables,
which is an important defect of single equation static production functions to estimate the elasticities (see Pereira and Flores, 1999; Karadag et al., 2004, for details).

In VAR modeling the value of a variable is expressed as a function of the lagged values of that variable and of all other variables in the model. It is also possible to represent a VAR model in a vector moving average form and thus the variables are expressed in terms of the current and the past values of the shocks. This allows us to trace out the time path of different shocks on the variables in the VAR system called impulse-response analysis.

Consider the VAR model,

\[ X_t = \sum_{i=1}^{p} A_i X_{t-i} + \varepsilon_t \]

where \( X_t \) is a \( m \times 1 \) vector of endogenous variables, \( \varepsilon_t \) is a vector of error terms.

The vector moving average of the representation of the VAR model is:

\[ X_t = \sum_{i=0}^{\infty} C_i \varepsilon_{t-i} \]

In the conventional method of application of impulse response functions, the errors were orthogonalised by standard Cholesky decomposition so that the covariance matrix of the residuals is diagonal. However, the changing of the order of variables may change the results in this procedure. Pesaran and Shin (1998) propose the generalized impulse response to overcome this problem. Generalized impulse response is invariant to the ordering of the variables in the VAR.

The \( m \times 1 \) vector of the generalized impulse response function of a unit shock to the jth equation on \( X_{t+n} \) is:
\[ \psi_j(n) = \frac{C_n \sum e_j}{\sigma_{ji}}, \]

where \( e_j \) is an \( m \times 1 \) vector with the \( j \)-th element equal to one and all other elements equal to zero and \( \sigma_{ji} \) denotes one standard error shocks.

It is possible to estimate elasticities from the estimated coefficients of the model in a single equation production function. However, the only way to obtain the elasticity estimates in VAR approach is to use impulse response functions that gives the estimates of the long run effects of different shocks.

**Estimation**

Before beginning the estimations, augmented Dickey-Fuller (ADF) test was used to specify the order of integration of the variables. ADF test statistics include a constant term. For the specification of the lag length, we used Akaike Information Criterion (AIC). In most of the cases the null hypothesis of a unit root could not be rejected at 5% significance level except for public capital series in some regions. However, further experiments with other specifications suggested that the null hypothesis could be rejected at 5% significance level. By taking this into consideration, we have concluded the nonstationarity of the series. Unit root tests were further conducted related to the first difference of the series. The output and private capital series were found to be I(1). Some of the employment and public capital series were found to be I(2) while most of them are found to be I(1). As a further experiment, following Pereira and Flores (1999), we conducted unit root test to the logarithm of employment and public capital to output ratios. If these ratios are I(1) since the output series are found to be I(1), employment and
public capital series should also be I(1). The results showed that all the ratios were I(1) except for public capital of Marmara, which is found to be I(1) with Phillips-Perron test at 1% significance level. Combining all of these results we have concluded that stationarity in first differences is a good approximation for the series⁴.

**VAR Specification**

VAR models for the seven regions are specified separately seven times by using five variables: public capital installed in the region itself, public capital installed in the other regions, private capital, labor and output. As all of the series are found to be I(1), VAR in first difference model was used. Consequently, all the variables are in growth rates. For all estimations constant term and trend are included to the model. We used one lag of each variable to keep the model simple and to avoid the problem of overparameterization.

In order to explore the spillover effects of public capital formation at the regional level, we used generalized impulse response function related with the estimated VAR models. In this context, we consider the impact of a one-time innovation of the growth rate of public capital installed in the region itself and of public capital installed outside the region on the private output at the regional level. Accumulated impulse response function consists of the accumulated changes in the growth rate of the variables. We give the accumulated impulse response functions for Marmara region in Figure 2 and Figure 3 as an example.

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⁴ The results are available upon request.
As can be seen in Figure 2, the value of the accumulated impulse response for the 20th year is positive for the public capital inside and output. Similarly, the value for the same year is positive for public capital outside and output. The ratios of these numbers can be interpreted as the long term accumulated elasticities.
4. Results

As it was mentioned earlier, the empirical results are based on impulse response function related with region specific VAR model. Table 2 presents the long-term accumulated elasticities related to public capital installed inside and outside the regions. It should be mentioned that long term is considered as the time horizon over which the growth effects of innovations disappear, i.e. impulse response functions converge. Accordingly, we have considered 20 years as the long term in our study. The long term accumulated elasticities show the total percentage change in private sector output for long term percentage change in public capital, which are calculated from the accumulated impulse response numbers. The effects of public capital installed outside the region give a measure of the spillover effect of public capital formation captured by each region. The estimation results are given in Table 2.
Table 2: Long-Term Accumulated Elasticities of Output with Respect to Public Capital Installed in the Region and Outside the Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Public Capital Inside</th>
<th>Public Capital Outside</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aegean</td>
<td>0.029</td>
<td>-0.316</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>0.004</td>
<td>-0.955</td>
</tr>
<tr>
<td>Marmara</td>
<td>0.080</td>
<td>0.347</td>
</tr>
<tr>
<td>Central Anatolia</td>
<td>-0.027</td>
<td>0.232</td>
</tr>
<tr>
<td>Black Sea</td>
<td>0.040</td>
<td>-1.180</td>
</tr>
<tr>
<td>South Eastern Anatolia</td>
<td>0.186</td>
<td>0.423</td>
</tr>
<tr>
<td>Eastern Anatolia</td>
<td>2.230</td>
<td>-1.150</td>
</tr>
</tbody>
</table>

As can be seen from the table, the results show that the effects of public capital formation installed inside the region on the output of private manufacturing industries are positive for all regions except for Central Anatolia. Also, the estimation results suggest that the regional outputs of Marmara, Central Anatolia, and South Eastern Anatolia regions are positively affected by public capital installed outside of these regions, while the outputs of other regions are negatively affected by the public capital. The positive spillover effect of Marmara region is not surprising, as this region constitutes approximately 60% of private manufacturing output in Turkey and attracts the biggest share of the public investments (around 30%)\(^5\). Public investments in this region promote growth through regional agglomeration economies. On the other hand, the negative spillover effects of public capital in some regions might well be explained due to the fact

\(^5\) See Karadag et al., 2004.
that when input factors are mobile, public capital installed in one region can draw manufacturing production away from the other regions (see also Moreno and López-Bazo, 2003).

Compared to the results reported in Karadag et al. 2004, the estimated long term elasticities of the present study regarding public capital installed in each region have the same sign for the four regions namely, Agean, Marmara, South Eastern Anatolia, and Eastern Anatolia, and have opposite sign for the rest of the regions. Moreover, the coefficients of elasticities are slightly lower in the present study compared to the previous one. Hence, the results of the present study suggest that the effects of public capital on regional private output can change when we take spillover effects into account.

5. Conclusion

In this study, we analyzed the spillover effects of public capital formation on private sector performance at the regional level in the Turkish manufacturing industries. Our empirical results are based on VAR estimates using private output, labor, capital, and public capital installed inside and outside the region.

The results indicate that public capital installed in the region affects private sector performance positively in all regions except for Central Anatolia. On the other hand, the positive spillover effects of public capital only can be seen in three regions, namely, Marmara, Central Anatolia, and South Eastern Anatolia.
The findings of this study also suggest that in order to measure the effects of public capital on regional economic growth, one should also take the spillover effects into account.

Moreover, the results of the study imply that the presence of negative and positive spillover effects of public capital in the Turkish regions gives rise to imbalanced regional growth. Especially, the existence of negative spillover effects of public capital like in Eastern Anatolia means that developed regions like Marmara may attract factors of production at the expense of less developed regions. Therefore, we can conclude that more public investments should be directed towards less developed regions in order to reduce regional disparities.

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