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THE RELATIONSHIP BETWEEN PUBLIC INFRASTRUCTURE AND ECONOMIC GROWTH IN TURKEY*

Tuncay SERDAROĞLU**

Abstract

As the effect of global economic crisis has still been continuing, the appeal to public infrastructure investments has been discussed widely by prominent economic agencies in an environment of weak global demand. Motivated by this debate, this paper investigates the importance of the public infrastructure investment in Turkish economy. By employing a Cobb Douglas production function estimation approach, output elasticity of public infrastructure investments under both constant returns to scale and variable returns to scale is estimated. According to estimation results, total public infrastructure capital investments are found to be significant to boost economic growth. Further, considering the size of the elasticities found for OECD countries and Turkey, investing in public infrastructure is expected to be more effective in Turkey compared to its OECD counterparts.

Key Words: Public Infrastructure Investments, Physical and Social Infrastructure, Capital Stock, Output Elasticity, Turkey

Jel Classification: E22, H00, O11, O41

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TÜRKİYE'DE KAMU ALTYAPI YATIRIMLARI VE BÜYÜME İLİŞKİSİ*

Tuncay SERDAROĞLU**

Özet

Küresel ekonomik krizin etkilerinin düşük küresel talep ortamıyla devam etmekte olduğu koşullarda, kamu altyapı yatırımlarına yönelim yeniden gündeme gelmiştir. Bu çalışmada, kalkınma hedeflerine ulaşmada kamu altyapı yatırımlarının Türkiye için ne ölçüde önemli olduğu incelenmektedir. Cobb-Douglas üretim fonksiyonu yaklaşımı kullanılarak ölçeğe göre sabit getiri ile değişken getiri varsayımları altında kamu altyapı yatırımlarının milli gelir esneklikleri hesaplanmıştır. Analiz sonuçları, toplam kamu altyapı yatırımlarının ekonomik büyümeyi artırmada anlamlı olduğunu göstermiştir. Türkiye ve OECD ülkeleri için hesaplanan esneklikler dikkate alındığında, Türkiye'de kamu altyapı yatırımlarının büyüme etkisinin OECD ülkelerine kıyasla daha büyük olacağı düşünülmektedir.

Anahtar Kelimeler: Kamu Altyapı Yatırımları, Fiziki Ve Sosyal Altyapı, Sermaye Stoku, Milli Gelir Esnekliği, Türkiye

Jel Sınıflaması: E22, H00, O11, O41

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1. Introduction

Investments in modern infrastructure are regarded as the foundations for economic development and growth. Modern and well-functioning infrastructure sectors like energy, water, transport, digital communications, power transmission lines, waste disposal networks, and social sectors like education and health are all essential for the success of a competitive modern economy. Studies have shown that well-designed infrastructure investments create long term economic benefits. Infrastructure investments can increase potential economic growth and productivity, and also they can provide significant positive spillovers in the economy. For example, large-scale infrastructure investments maintained in China, South Korea and Taiwan would explain their economic successes (Aghion et al., 2013, Embassy of the USA, 2012).

Five years after the global financial crisis, the merits of public infrastructure are again considered by international and governmental agencies in terms of their role in giving momentum to the economy. For example, IMF (2014) suggests that it is the right time to raise public infrastructure investments in countries where there are infrastructure bottlenecks as borrowing costs are still low and demand is weak. Also, according to the literature, infrastructure investments have direct and indirect effects on total output. As investment expenditures increase aggregate demand in the economy, realized infrastructure investments directly contribute to GDP formation. Additionally, these investments create an environment in which productive inputs would be utilized more efficiently, and may stimulate private sector economic activities. Therefore, total factor productivity, which is crucial in terms of sustainable economic growth, would be enhanced in the economy (Aghion et al., 2013; Bayraktutan, 1992). The aim of this study is to explore the role of public infrastructure investment on output in Turkey by taking both public physical and social infrastructure investments into account.

As physical infrastructure investments and social infrastructure investments would have different impact on output, separate analysis is also conducted for social public infrastructure investments and physical public infrastructure investments by using production function estimation methodology. In the next two sections, we present the studies analyzing the impact of public infrastructure investments in other economies and Turkey. In the fourth section, data and methodology are discussed, and estimation results for Turkish economy are presented in the fifth section. Finally, conclusion is given in section 6.

2. Public Infrastructure in the World

Infrastructure investments tend to be large-scale, expensive and long-term in nature so that private sector cannot maintain them on its own, therefore governments will play a vital role in planning, delivering and financing infrastructure investments (Aghion et al., 2013). In recent years, however, both in Turkey and in other major economies, public-private partnership initiatives are built in order to maintain and finance such big projects as new needs and technologies emerge. Private sector and also multilateral organizations can play a role in supplying valuable oversight and technical expertise to these infrastructure projects which constitute an important ingredient in successful completion of these expensive projects.

While the literature has not revealed a clear convergence in terms of the size of the output elasticity of public infrastructure capital, we find that public infrastructure capital have in general positive and statistically significant effects on output, though some studies find insignificant and negative effects considering different indicators of public capital. It is not surprising that the results are subject to change when different countries, time frames and types of infrastructure are considered (European Commission, 2014). For example, IMF (2014) also concluded that the effect varies depending on whether the countries analyzed belong to low income developing countries or advanced/emerging market economies. Studies in general, use the production function approach to reveal respective elasticities. Below, certain studies using this approach are presented with their major outcomes.

Calderon, Moral-Benito and Serven (2011) offer an empirical evaluation of long-run elasticity of output with respect to infrastructure covering 88 countries for the years 1960-2000. By relating GDP to human capital, physical capital, and a measure of infrastructure, they found a statistically significant index range of 0.07-0.10 for output elasticity of infrastructure. Canning and Bennethen (2000), use a panel data for 62 countries over the period 1960-1990. By imposing constant returns to scale, the output elasticity of public physical infrastructure measured as roads and electricity separately are found to be as 0.09, and the elasticity is the same for both.

There are also some studies pointing out insignificant and negative effect of public capital investments on output. For example, Canning, Fay and Perotti (1994) use data for road, rail, electricity and telecom as public physical infrastructure and investigate its contribution to output growth for 98 countries over the years 1960-1985. The results show that telecom and electricity infrastructure is significant while the effects of road and rail infrastructure are unclear. Garcia-Mila et al. (1996) employ highways next to water and sewer and other public capital with cross-section data and investigate the effects on gross state output for 48 US states over 1970-1983. Negative and statistically insignificant results are found. According to Nannan and Jianing (2012), the public infrastructure investments play a vital role in raising long-term economic growth rate of China. Using a data set for 1988-2007, they find that 1 percent increase in public infrastructure capital raises the output by nearly 0.3 percent.

There are also numerous studies conducted for OECD countries. Roller and Waverman (2001) conduct an analysis for 21 OECD countries for the years 1971-1990 where they use a Cobb-Douglas type aggregate production function and penetration rate measured by main lines per capita as public infrastructure. The results indicate that one third of contribution to GDP growth comes from infrastructure investments, though the impacts on growth are non-linear. That is they become much larger when threshold of universal service is exceeded. Egert, Kozluk and Sutherland (2009) employ an exogenous growth model where the total of roads, railways, electricity and telecom are considered as public physical infrastructure. 24 OECD countries were analyzed over 1960-2005. Although, no effect of public physical infrastructure on growth was found, only electricity is indicated to have a significant effect with a coefficient of 0.17. Broyer and Gareis (2013) analyzed the output elasticity of public infrastructure investment for France, Italy, Germany and Spain and conduct a VAR model by using quarterly data for the years 1995-2011. Weighted average of respective elasticity is found as 0.17. An important conclusion from the study is that infrastructure investment affects economic activity more in recessions in comparison to stable macroeconomic conditions. In one of more recent studies Bom and Ligthart (2014) collect 578 estimates for the years of 1983-2008 from 68 studies where 31 of them on the United States and the rest of them on OECD countries. The main conclusion reported from these studies is that the estimates are biased by econometric specifications and data. The authors find out that there is a short-run elasticity of 0.051 and a long-run elasticity of 0.14 when public capital is installed by national governments.

There are also some studies that investigate the productivity enhancing effects of public infrastructure investments. Aschauer (1989) finds a large return to public investment in the United States and even attributes productivity slowdown in the 1970’s to the decline in public investment. In line with this study, Munnel (1992) reveals that public capital investments has stimulating effect on private investment, output and employment growth. There are also arguments on the effective use of public capital. According to Hulten (1996), 25 percent of growth difference between East Asian and African countries stem from the inefficient use of public infrastructure capital. Management and financing aspect of public capital are also considered important for the relationship between productivity and infrastructure capital. For example, Aschauer and Lachler (1998), based on the analyses for 46 developing countries for the period of 1970 and 1990, find a positive effect of infrastructure investments only if the level of public debt stock is low. Finally, according to Loko and Diouf (2009) the overall impact of government size on productivity growth is not clear.

3. Public Infrastructure Investments in Turkey: Stylized Facts

Public infrastructure investments have an important role in Turkey aimed at reaching its development objectives. As a result of private sector oriented development model adopted in 1980’s, public investments in industrial sector diminished gradually and investments towards infrastructure came into prominence in government budget. In this framework, large scale infrastructure investments in transportation, irrigation, energy, information and technology, health and education sectors have constituted an important part of public investments especially in recent years. Moreover, besides public resources, public-private partnership (PPP) models along with alternative financing models are mostly benefitted in order to meet increasing financing needs of this infrastructure investment projects in Turkey as a rapidly growing country (Ministry of Development, 2012).

There are certain studies for Turkey investigating the role and importance of public infrastructures in explaining economic growth analytically with respect to its different features. One of these prominent studies belongs to Pekbaş (2008) who investigates the effects of public infrastructure investments on growth over the years 1980-2004 by referring to the production function and VAR method. In this study, public infrastructure investments are decomposed into four subsectors, namely energy, transportation, telecommunications and water facilities and sewers. According to results, both VAR and production function methods reveal significantly positive effect of public infrastructure investments on growth. Especially, transportation&telecommunications infrastructure investments and energy infrastructure investments are found to be prominent. Finally, the output elasticity of total public infrastructure capital is found to be 0.124 in this study.

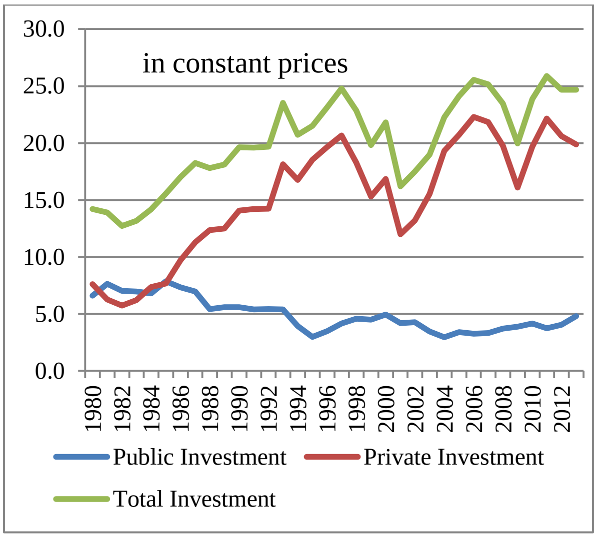
In one of the recent studies Eruygur, Kaynak and Mert (2012) analyze the short and long-term relationships between the transportation&communication capital and output for Turkey. The result derived from the impulse response function reveals a positive crowding in effect of transportation–communication capital on non-residential total capital formation and its significant impact on economic growth.

On the other hand, İsmihan, Metin-Özcan and Tansel (2005) provide the stylized facts related to investment performance of Turkey over the period 1963-1999 by using cointegration and impulse response analyses. They indicate that public investments in Turkey were seriously affected by macroeconomic instabilities in the Turkish economy which became an impediment particularly to infrastructural component of public investments. This situation led to even reverse the complementarity between public and private investment in the long-run. It is also indicated that this result may explain why there is not a clear crowd-in effect between public and private investment.

Finally, Uzbay Pirili and Lenger (2012) put forward the importance of public capital and social capital on regional development in Turkey. According to new regional development view, the investments towards improving human capital and social infrastructure are as significant as physical infrastructure investments. In fact, the former investments are necessary condition for physical infrastructure investments to be effective and beneficial. They show that in Turkey, the effects of public physical infrastructure and social infrastructure capital on growth varies in developed and developing provinces in Turkey with respect to their human development levels over the period 1987-2001.

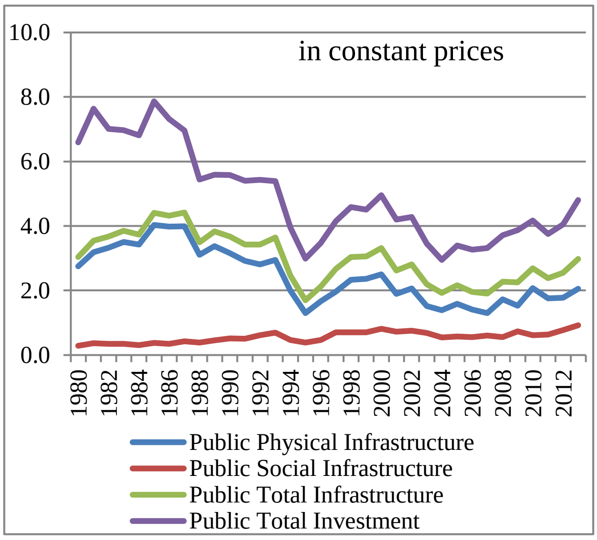
Considering the path of investments in Turkey, we see that private investments are determinant in the course of total investment in Turkey. Furthermore, investment expenditures displayed sharp declines in crises years of 1994, 2001 and 2009. One remarkable observation is that public investments showed a declining trend from the beginning of 1980's until 1994 crisis. Since then, the share of public investments swings around 3 to 5 percent in GDP (Figure 1). As İsmihan et al. (2005) also indicate, the fall in public investments may stem from macroeconomic instabilities that Turkish economy experiences since 1980's.

Figure 1: The Share of Investments in GDP



Source: TURKSTAT

Figure 2: The Share of Public Investments in GDP



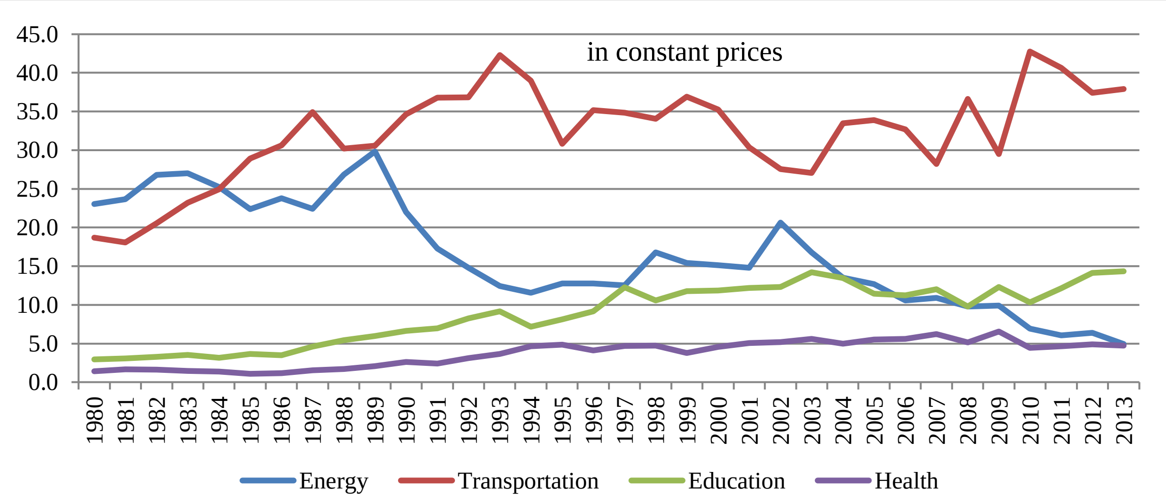
Source: TURKSTAT, Ministry of Development

In parallel with the definition in the literature, total public infrastructure investment is decomposed into physical and social infrastructure investment. While, physical infrastructure investment is composed of energy and transportation investments, social infrastructure investment includes health and education investments. Accordingly, considering the shares of two kinds of public infrastructure investments in Turkey in retrospect, it is seen that public physical infrastructure outweighs public social infrastructure over the whole period. After closing the gap in between somewhat in the 1990's, the discrepancy of the respective shares, which is about 1 percentage point of GDP, seems to be enduring in the last decade. It is thought that the withdrawal of public sector from production activities and privatizations have been determinant in this development during the considered time period. It is also realized that the trend in infrastructure investments are determinant in the course of public total investment (Figure 2).

Analyzing the sectoral composition shares of physical and social infrastructure investments in total public investments in constant prices, it is observed that the declining share of energy infrastructure investment is remarkable. The dramatic fall in energy investments since 1990's from the levels of 30 percent to 5 percent level seems to be the main reason of the deceleration of the share of public infrastructure investment in GDP during the last half of 1980's and the first half of 1990's. The shift in the public policy towards privatization in energy sector is the main determinant in this development.[1] While the share of transport and education investments displays an upward trend, the share of health investments stabilizes nearly at 5 percent level in total public fixed capital investments (Figure 3).

[1] It is observed that public sector especially exited from the production and distribution of the electricity regarding the energy sector.

Figure 3: Sectoral Share of Public Infrastructure Investments in Public Investments



Source: TURKSTAT, Ministry of Development

4. Data and Methodology

This study presents an empirical investigation of the relationship between public infrastructure investments and economic growth in Turkey using a dataset over the years of 1980-2013. In line with the literature, it is aimed to reveal the respective output elasticities of public infrastructure investments, whether public infrastructure capital has an effect on output growth and its magnitude. Public fixed capital investments are disaggregated into physical and social capital investments in order to analyze both the separate and the combined effect of these investments on stimulating growth.

Drawing on TURKSTAT database, the figures related to gross domestic product (GDP), total fixed capital investment, public fixed capital investment and employment figures are taken from Turkish Statistical Institute (TURKSTAT) and all variables are used in constant prices.

This paper estimates the contribution of public infrastructure capital investments to aggregate output using a production function approach. Since, one of the main aims of the study is to find out output elasticities of different types of capital, it is important to estimate respective capital stock variables accordingly.

In this framework, firstly, total capital stock for the whole economy is estimated. In order to decompose public fixed capital investments into physical and social capital investments, sectoral decomposition of public fixed capital investment figures in constant prices provided by the Ministry of Development are used. By these sectoral shares of energy and transportation in total public fixed capital investments, it is harmonized with total public fixed capital investment data provided by TURKSTAT and so public physical fixed capital investments are obtained. The same procedure is also followed in order to obtain public social fixed capital investments where public social investments consist of health and education investments.

After calculating respective capital stock series, other capital is derived by subtracting public physical and public social capital stock from total capital stock calculated for the total economy. Finally, total employment is also used as an input in the production function.

Because, there is no officially published data of capital stock for Turkey[2], capital stock figures are estimated by using the perpetual inventory method, which is widely used in the literature.[3] According to this method, certain assumptions are required about the parameters such as the service lives of investments, depreciation rate and the discard pattern of depreciation as mentioned in Meinen, Verbiest ve Paul de Wolf (1998).

Since, there is no study about the estimation of service life of investment for Turkey, we draw on OECD (1999) for the assumption on the service lives of sectoral investments by taking OECD country averages as representative for Turkey. Then, we calculate service lives for physical and social capital stock by weighting them with their average shares in public sector fixed capital investments. In addition to this, the service life of total capital is calculated by weighting the service lives of all sectoral investment items with their respective average shares in total fixed capital investments. Since, we have service lives for total sectoral fixed capital investments, the service lives of sectoral fixed capital investments by assumption are taken as common for both public and private sectors. Finally, the depreciation rate is obtained for each kind of capital according to the service life of investment.[4] Table 1 shows OECD estimation for sectoral service lives of investments and the respective sectoral shares of investments in their own groups. Accordingly, the service lives of the capital types used in this study and their related depreciation rates are presented in the Table 2 below.

Table 1: Service lives and sectoral average shares of capital stock figures (in constant prices)

Sectors	**Service lives (years) OECD country averages**	**Average shares of total fixed capital investments over the period 1980-2013**	**Average shares of public fixed capital investments over the period 1980-2013**
Energy	31	6.6	16.4
Transportation	25	19.6	32.2
Education	29	2.8	9.1
Health	29	2.9	3.9
Agriculture	23	5.1	9.4
Mining	23	2.3	3.5
Manufacturing	26	24.9	5.9
Tourism	29	3.7	0.9
Residence	62	24.7	1.7
Other Services	26	7.4	17.3

Source: Saygılı and Cihan (2008), author calculation.

[2] Although, there is no officially published data of capital stock for Turkey, one can find estimations on capital stock for Turkey in Uygur (1990), Maraşlıoğlu and Tıktık (1991), Saygılı and Cihan (2008), Saygılı, Cihan ve Yurtoğlu (2005), Yaşar (2008) and Serdaroğlu (2013).

[3] One can refer to OECD (2009) in order to find out conceptual explanations on how to estimate capital stock and the application of the perpetual inventory method.

[4] The theoretical explanation behind the calculation of the depreciation rate is provided in Appendix 2.

Table 2: The service lives of capital stock and their depreciation rates

Type of Capital Stock	Service lives of capital stock (n, years)	Depreciation rate (1/n)
Public Physical Infrastructure Capital	27	0.0370
Public social infrastructure capital	29	0.0345
Total capital stock in the economy	35	0.0285

Source: Author calculation.

Finally, discard pattern of investments are also taken into consideration in estimating the capital stock. While, there is alternative discard pattern with respect to time periods, it is assumed that investments display a linear discard pattern in this study as assumed in OECD (1999) and Meinen et al. (1998). After determining the depreciation rate and the discard pattern of investments, initial capital stock for each type of investments defined in this study can be calculated for the initial year 1980 as in the study of Coe and Helpman (1995) indicated as below:

$$K_0 = I_0/(\mathrm{a} + g) \tag{4.1}$$

"K_0" in the above equation denotes initial capital stock, "I_0" represents initial fixed capital investments, "a" and "g" correspond to the depreciation rate and the average growth rate of fixed capital investments between 1980-2013 in Turkey. Then, capital stock series for public physical infrastructure, public social infrastructure and total capital stock are formed by using the formula below:

$$K_t = I_{t-1} + (1 - \mathrm{a})K_{t-1} \tag{4.2}$$

Accordingly, current capital stock is built by adding last year's fixed capital investment to last year's depreciated capital stock level. So, it is assumed that current fixed capital investment becomes only operational in at least one year period[5].

The production function including capital and labor can be written as:

$$Y_t = F(A_t, K_t, L_t) \quad \text{where,} \tag{4.3}$$

Y_t is the real GDP;

A is the total factor productivity;

K_t is the total capital stock in the economy;

L_t is the number of total employment;

t is the time subscript.

[5] An alternative capital stock series is also calculated by using current fixed capital investments and then the correlation between the two capital stock series are calculated. The correlation between the two alternative total capital stock series is found as 0.99. Furthermore, to address possible endogeneity issues, the estimation is repeated with one period lagged value of the alternative capital stock series and estimation results are provided in Appendix 4. It is observed that estimation results of the both models are quite similar.

In this analysis, production function is regarded as Cobb-Douglas production function with a Hicks-neutral technological development which can be defined as follows:

$$Y_t = A_t \, K_t^a L_t^b \quad \text{where,} \tag{4.4}$$

a and b represent the output elasticity of capital and labor, respectively. Then, total capital is disaggregated in the production function to also include public physical and public social infrastructure capital, which can be written as:

$$Y_t = F(A_t, P_t, S_t, KOTH_t, L_t) \quad \text{where,} \tag{4.5}$$

P_t is the capital stock of public physical infrastructure;

S_t is the capital stock of public social infrastructure;

$KOTH_t$ is the non-infrastructure capital stock or other capital;

In this analysis, production function is regarded as Cobb-Douglas production function with a Hicks-neutral technological development which can be defined as follows:

$$Y_t = A_t \, P_t^\alpha \, S_t^\beta \, K_t^\gamma L_t^\delta \quad \text{where,} \tag{4.6}$$

α, β, γ and δ represent the output elasticity of public physical infrastructure capital, public social infrastructure capital, other capital and labour respectively. Unit root tests for all the variables in the regression suggest non-stationarity of the variables at levels (Table 3). While total capital, public physical infrastructure capital and other capital are integrated of order 2 (i.e. I(2)), the rest of all variables are found as I (1). Therefore, we follow to find out whether there is cointegration among the variables in order to avoid attaining spurious regressions.

Table 3: ADF test statistics for variables' stationarity

H_0: unitary root		**None**	**Intercept**		**None**	**Intercept**
Variables		t-statistic / p-value	t-statistic / p-value		t-statistic / p-value	t-statistic / p-value
Output	Y_t	5.118 (1,000)	1.363 (0.998)	ΔY_t	-3.431 (0.001)	-5.360 (0.000)
Public Physical Infrastructure Capital	P_t	1.851 (0.982)	-1.025 (0.732)	ΔP_t	-0.841 (0.344)	-2.763 (0.075)
Public Social Infrastructure Capital	S_t	2.626 (0.997)	9.504 (1.000)	$\Delta^2 S_t$	-6.261 (0.000)	-6.559 (0.000)
Total Public Infrastructure Capital	$P_t + S_t$	2.162 (0.991)	0.320 (0.976)	$\Delta(P_t + S_t)$	-0.301 (0.569)	-2.692 (0.086)
Total Capital Stock	K_t	2.859 (0.998)	2.637 (1.000)	$\Delta^2 K_t$	-5.420 (0.000)	-5.601 (0.000)
Other Capital Stock	$KOTH_t$	2.587 (0.997)	2.368 (0.999)	$\Delta^2 KOTH_t$	-5.058 (0.000)	-5.208 (0.000)
Labor Input	L_t	4.339 (1.000)	1.348 (0.998)	ΔL_t	-3.333 (0.002)	-4.646 (0.000)

Note: "Δ" and "Δ^2" represent the difference operator of order 1 and 2, respectively.

In this analysis, we also test the hypothesis about returns to scale assumptions. In Cobb-Douglas type of production functions, returns to scale specification are important because of finding not only the reasonable parameters but also suggesting some practical arguments about infrastructure investments in this case. It may be reasonable to think production functions including infrastructure capital as revealing increasing returns to scale because infrastructure investments are generally realized in large units. Hence, they may increase the scale of total production by leading to other capital and labor to be utilized better and more efficiently (Wessels, 1997).

We begin firstly to reveal the output elasticities of capital and labor by using the aggregate capital for the economy and the regressions are run both under constant returns and variable returns to scale assumptions. So the equations (4.7) and (4.8) are provided for this purpose.

$$LnY_t = Ln\, A_t + aLnK_t + bLn\, L_t \tag{4.7}$$

$$LnY_t = Ln\, A_t + a'LnK_t + (1 - a')Ln\, L_t \tag{4.8}$$

Then, disaggregated capital stocks are used in the regressions under different returns to scale assumptions. We begin with the production function operating under variable returns to scale so that the analytical results are attained from an unrestricted form of regression. So, the coefficients of factors of production can exceed one. Furthermore, we include both public physical and public social infrastructure capital separately in order to reveal the respective importance of different kinds of public infrastructure investments. The equation (4.9) below provides this hypothesis testing.

Taking the log of the both sides of the equation (4.6), we have the following equation:

$$LnY_t = Ln\, A_t + \alpha LnP_t + \beta Ln\, S_t + \gamma Ln\, KOTH_t + \delta LnL_t \tag{4.9}$$

We continue with the unrestricted form of regression, however, public physical infrastructure and public social infrastructure are taken as together and denoted as total public infrastructure. Other capital is the same as before. The reason of this aggregation of public capital is to see the complementary effect of respective investments. Then, we run this specification under variable returns to scale as indicated in equation (4.10).

$$LnY_t = Ln\, A_t + \alpha' Ln(P_t + S_t) + \gamma' Ln\, KOTH_t + \delta' LnL_t \tag{4.10}$$

Now, we assume that there is a constant returns to scale of factors of production, because there is a limit to economies of scale in the economy. So, we run the same regressions as indicated in (4.9) and (4.10) under constant returns to scale. Under this condition, the sum of all coefficients of production factors is equal to 1, so when we substitute $\delta = 1\text{-}\alpha\text{-}\beta\text{-}\gamma$ into equation (4.9), we have the following equation:

$$LnY_t = Ln\, A_t + \alpha'' LnP_t + \beta'' Ln\, S_t + \gamma'' Ln\, KOTH_t + (1 - \alpha'' - \beta'' - \gamma'')LnL_t \tag{4.11}$$

Finally, we look at how the results change when we take total public infrastructure capital into account under constant returns to scale. Hence, we estimate the following regression:

$$LnY_t = Ln\, A_t + \hat{\alpha} Ln(P_t + S_t) + \hat{\gamma} Ln\, KOTH_t + (1 - \hat{\alpha} - \hat{\gamma})LnL_t \tag{4.12}$$

Then, in order to decide on returns to scale assumption, we can test the null hypothesis by using the test statistic below:

$$F_p = \frac{S_R - S_U}{S_U} * \frac{n}{q} \sim F_{q,n} \quad (4.13)$$

where "S_R" and "S_U" are sum of square residuals of restricted and unrestricted models, respectively. Further, "n" and "q" are degrees of freedom of unrestricted model and the number of restrictions, respectively.

5. Analyses on Estimation Results

By using the analytical framework presented above, dummy variable (D2001) is added for 2001 economic crisis in Turkey to all regressions in order to adjust the fitted values. Since this is a structural framework set to attain structural parameters on the economy, one would not like to deal with the unintended econometric diagnostic biases. However, on behalf of analytical rigor, we would like to prefer White transformation for all of the regressions. Also, the analytical results are presented in Table 4 below[6].

In order to decide on the returns to scale assumption, we begin with testing the hypothesis of constant returns to scale regarding equations (1) and (4) which is equivalent to the null hypothesis that the sum of total capital and labor coefficients equals to 1. Then, equation (1) represents the unrestricted model, while equation (4) represents the restricted model.

H_o: a + b = 1 for equation 1.

H_1: a + b ≠ 1

$$F_1 = \frac{0.068965 - 0.067604}{0.067604} * \frac{30}{1} = 0.604 < F_{q,n} \sim F_{1,\ 30}^{0,05} = 4.17$$

Accordingly, the null hypothesis cannot be rejected, so we can consider the equation (4) which represents constant returns to scale production technology. Then, we continue to test the hypothesis of constant returns to scale regarding equations (2) and (5) which is equivalent to the null hypothesis that the sum of labor, physical infrastructure capital, social infrastructure capital and other capital coefficients equals to 1.

[6] Since the aim of this study is to investigate the output elasticities of public infrastructure investments, one should be prudent to also infer public capital causally affect growth. However, as capital stock figures used in the regressions are attained by using the lagged terms of fixed capital investments suggested by the perpetual inventory method, endogeneity problem is partially addressed.

Table 4: Estimation Results

Dependent Variable: lnY_t						
	Variable Returns to Scale			**Constant Returns to Scale**		
	(1)	(2)	(3)	(4)	(5)	(6)
c	4.3322*** [1.243]	4.3638* [2.3244]	3.4820** [1.5273]	3.2899*** [0.1370]	4.0960* [2.0751]	2.9906*** [0.4800]
lnP_t		0.1106 [0.1718]			0.1015 [0.1674]	
lnS_t		0.0906 [0.2898]			0.1217 [0.2715]	
$ln(P_t + S_t)$			0.2318* [0.1207]			0.2417* [0.1188]
$lnKOTH_t$		0.3638 [0.3295]	0.4124*** [0.0812]		0.3117 [0.2848]	0.3917*** [0.0465]
lnK_t	0.5916*** [0.066]			0.5447*** [0.0154]		
lnL_t	0.2592 [0.250]	0.3708 [0.3498]	0.2946 [0.2635]	0.4553	0.4651	0.3666
D2001	-0.137*** [0.0141]	-0.1418*** [0.0160]	-0.1419*** [0.0154]	-0.1328*** [0.0100]	-0.1402*** [0.0132]	-0.1402*** [0.0123]
R-squared	0.9878	0.9871	0.9875	0.9875	0.9871	0.9874
F-statistic	807.4	429.1	571.8	1226.5	553.8	786.2
Prob(F-statistic)	0.000	0.000	0.000	0.000	0.000	0.000
Sum of Square Residuals	0.0676	0.07120	0.0692	0.0690	0.07141	0.0694
Number of observations	34	34	34	34	34	34
Wald F-statistic	1281.8	963.7	1463.7	653.6	406.4	589.2
Prob(Wald F-statistic)	0.000	0.000	0.000	0.000	0.000	0.000
HC Test: White Prob.	0.577	0.915	0.7571	0.606	0.8058	0.5871

Note:

1: OLS regressions are run by using E-Views 8.

2: “*”, “**” and “***” indicate 10 percent, 5 percent and 1 percent measurement error, respectively.

3: Standard errors are displayed in the brackets.

4: Because constant returns to scale is a restricted form of regression, only the coefficient is provided for the output elasticity of employment.

$H_o: \alpha + \beta + \gamma + \delta = 1$ for equation 2.

$H_1: \alpha + \beta + \gamma + \delta \neq 1$

$$F_1 = \frac{0.071408 - 0.071198}{0.071198} * \frac{28}{1} = 0{,}0826 < F_{q,\,n} \sim F^{0{,}05}_{1,\ 28} = 4.20$$

Hence, the null hypothesis cannot be rejected, so we can consider the equation (5) which represents constant returns to scale production technology. Now, we continue to test the hypothesis of constant returns to scale regarding equation (3) (unrestricted model) and equation (6) (restricted model) which is equivalent to the null hypothesis that the sum of labor, total public infrastructure capital and other capital coefficients equals to 1.

$H_o: \alpha' + \gamma' + \delta' = 1$ for equation 3.

$H_1: \alpha' + \gamma' + \delta' \neq 1$

$$F_1 = \frac{0.069407 - 0.069196}{0.069196} * \frac{29}{1} = 0{,}0884 < F_{Table} \sim F_{1,\ 29}^{0{,}05} = 4.17$$

Therefore, the null hypothesis cannot be rejected, so we consider the equation (6) which represents constant returns to scale production technology. So, we can continue with the equations under constant returns to scale.

When we consider the equation (4), it is observed that the elasticity of total capital and labor are staying around 0.54 and 0.46, respectively. When we disaggregate total capital, we see that public physical and social infrastructure capital are not significant on its own, as it is shown in the equation (5). However, one should always keep in mind that physical and social infrastructure can be evaluated as complementary.

When we combine public physical and social infrastructure capital together and include this variable as the total public infrastructure capital in the equation (6), then the picture changes. It can be observed that total public infrastructure capital has significantly positive effect on output. Regarding the equation (6), one percent increase in total public infrastructure capital leads to a 0.24 percent increase in total output. Also, the output elasticity of other capital, which includes total capital stock except total public infrastructure capital in the economy, is around 0.4 percent. Hence, the results reveal that capital accumulation is the main factor behind Turkey's growth performance which supports this fact once again as shown in many previous studies. Apart from this, 1 percent increase in total employment is found to increase output by 0.37 percent accordingly. Finally, the parameters calculated for other capital and employment in the fourth regression reveal consistency with production function coefficients of capital and labour calculated for Turkish economy in a number of studies, which also show that the returns to capital exceeds the returns to labor in explaining aggregate output.[7]

According to Stock (1987), OLS estimation results of the output elasticities presented in Table 4 would yield super consistent estimates of the existing cointegrating vector. Due to the variables of different orders in the regression, we will follow the Engle-Granger procedure with I(2) variables for the equation (6)[8]. According to Engsted, Gonzalo and Haldrup (1997), there can be multicointegration which refers to a situation that a linear combination of I(2) and I(1) variables is integrated of order zero. Hence, it is possible to have a long-run equilibrium relationship which can be derived from one-step procedure in the form:

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[7] One can refer to the studies of Saygılı and Cihan (2008), Yaşar (2008) and Saygılı, Cihan ve Yurtoğlu (2005).

[8] The output elasticities with respect to the equation (4) also would yield super consistent estimates of the multicointegrating vector whose existence is shown in the appendix 3.

$$LnY_t = Ln\,A_t + \hat{a}Ln(P_t + S_t) + \hat{b}Ln\,KOTH_t + \left(1 - \hat{a} - \hat{b}\right)LnL_t + \hat{c}\,Ln\Delta KOTH_t + \hat{e}$$
(5.1)

where K_t is I(2) variable, while the rest of the variables are I(1). Hence, the test allows to include up to two I(2) variables and an unrestricted number of I(1) variables as explanatory variables. In order to look at the stationarity of the residual "e_t", we estimate a regression of the form

$$\hat{e_t} = a_1\hat{e}_{t-1} + \varepsilon_t \qquad (5.2)$$

In the equation 5.2, there is no need to include an intercept term, since it is a residual from a regression equation 5.1. The measurement result of equation 5.1 is provided in Table 5. Here, the parameter of interest is a_1. As we can see from Table 6, the null hypothesis is rejected, which means that the residual series do not contain a unit root (i.e. it is stationary). Therefore, it is possible to conclude that there is multicointegration.

Table 5: Cointegration Equation

Dependent Variable: LOG(Y)
Sample: 1981 – 2013
White heteroskedasticity-consistent standard errors & covariance

	Coefficient	Std. Error	t-Statistic	Prob.
c	3.034	0.481	6.304	0.000
$\ln(P_t + S_t)$	0.213	0.124	1.723	0.096
$\ln KOTH_t$	0.404	0.049	8.267	0.000
$\ln\Delta KOTH_t$	0.934	0.569	1.642	0.112
$\ln L_t$	0.383			
D2001	-0.137	0.011	-11.891	0.000
D1994	-0.114	0.020	-5.613	0.000

R-squared	0.989	Sum squared resid	0.055
Adjusted R-squared	0.987	Log likelihood	58.63
F-statistic	481.8	Durbin-Watson stat	0.970
Prob(F-statistic)	0.000		

Table 6: Cointegration Test

H_0: unitary root	**None**	**Intercept**
Variable	t-statistic / p-value	t-statistic / p-value
a_1	-3.181 (0.002)	-3.128 (0.034)

Note: a_1 is the parameter in the equation 5.2.

When we compare the results with the recent studies in the literature presented above, there are several points to be noted. In this study, the result attained for the output elasticity of public infrastructure capital for Turkey is close to the results found for the OECD countries in the studies of Egert, Kozluk and Sutherland (2009) and in Broyer and Gareis (2013), which is 0.17 in both of these studies. It is natural that the size of the output elasticity of public infrastructure capital is subject to change when different countries and time frames are considered. However, it is understandable that the size of the public infrastructure capital is greater than the one attained for mainly developed countries, because there is still a need of further public infrastructure capital investments and also its improvement in terms of quality in less developed regions in Turkey.

6. Conclusion

This paper has been prepared to investigate how important public infrastructure investment is for Turkey trying to achieve its development objectives. To this end, an empirical Cobb-Douglas production function is formulated for the time period of 1980-2013. In line with the literature, two types of public infrastructure investments are defined, namely public physical and public social investments. By calculating public physical infrastructure, social infrastructure capital and other capital respectively, we look at the output elasticity of respective factors of production under the assumptions of both constant returns to scale and variable returns to scale. The analytical framework allows investigating respective output elasticities of public infrastructure capital in terms of its subgroups and its combined effect.

According to the hypothesis testing of returns to scale, the functional form of production function is found as constant returns to scale. Then, the regression results attained under constant returns to scale clearly indicate that public infrastructure capital investments are significant to boost economic growth when we take public physical and public social infrastructure together into account. If we take them separately into account, then none of the coefficients can be found significant. This can be the result of the fact that public physical and social infrastructure investments display a complementary relation. Therefore, it is sound to consider the equation taking the combined effect into account.

When the combined effect of public physical and social infrastructure capital on growth is taken into account, the output elasticity of output is found as 0.24, which is somewhat greater than the respective size found for OECD countries. However, this finding is not surprising as Turkey is an emerging market economy and needs further public infrastructure capital to spur its growth. In this sense, the private sector is expected to benefit more from positive externalities from public infrastructure investments. Therefore, it is important for Turkey to invest more in public infrastructure, because it can also have a stronger growth effect compared to its OECD counterparts.

According to IMF (2014), increased investments towards infrastructure pave the way to a rise in output both in the short and the long run and especially during periods of economic stagnation and there is high investment efficiency. If we consider that the borrowing costs are still low and foreign demand is weak, Turkey can benefit from public infrastructure investments to stimulate growth. This will allow Turkey to benefit from both the direct contribution of public investments to economic growth and productivity gains expected from increasing productive activities of private sector using infrastructure as inputs in their activities.

Further, as underlined in the Tenth Development Plan (2014-2018), Turkey needs new public infrastructure projects in order to meet rising economic and social infrastructure needs as well as effective use of existing capital stock. Hence, selectively undertaken projects, strong project management, improved planning, implementation, monitoring and evaluation processes of public investment projects all are essential factors to these kinds of projects' success. Finally, if Turkey's infrastructure needs are clearly identified and met through efficient investments, then debt-financed projects could not create a significant concern about debt-to-GDP ratio.

It is thought that the importance of physical and social infrastructure are clear in terms of fostering economic growth in Turkish economy. Furthermore, increasing both the quantity and the quality of public infrastructure investments should be considered in order to support private sector investments. Also, investigating the role of infrastructure investments in reducing disparities among regions in the case of Turkey remains an important further research study. All in all, giving importance to public infrastructure investments can lead to prosperity in Turkey for the years ahead.

APPENDICES

Appendix 1. Data for production function (The series are in real terms.)

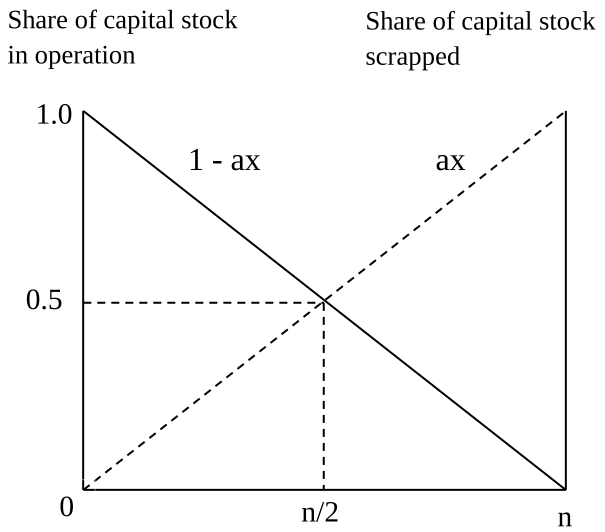
	Output	**Total Capital Stock**	**Public Physical Capital Stock**	**Public Social Capital Stock**	**Other Capital Stock**	**Employment**
1980	30,409,328	48,472,171	11,797,467	757,328	35,917,377	13,994
1981	31,886,191	51,414,325	12,197,898	818,323	38,398,104	14,115
1982	33,022,409	54,379,925	12,762,402	905,639	40,711,883	14,264
1983	34,663,955	57,034,763	13,387,276	988,874	42,658,614	14,410
1984	36,990,584	59,977,780	14,105,493	1,074,972	44,797,316	14,633
1985	38,559,523	63,516,044	14,848,798	1,151,615	47,515,631	14,882
1986	41,263,307	67,700,216	15,854,750	1,256,011	50,589,455	15,159
1987	45,177,429	72,796,011	16,910,273	1,353,713	54,532,026	15,508
1988	46,135,349	78,968,427	18,085,607	1,500,075	59,382,745	15,745
1989	46,251,445	84,927,629	18,848,189	1,627,972	64,451,467	16,160
1990	50,532,158	90,879,455	19,713,377	1,780,077	69,386,002	16,441
1991	51,000,345	98,212,035	20,580,619	1,980,019	75,651,398	17,105
1992	54,052,352	105,408,996	21,309,010	2,170,469	81,929,518	17,257
1993	58,399,252	113,041,774	22,036,307	2,429,187	88,576,280	16,406
1994	55,213,184	123,551,197	22,942,971	2,748,594	97,859,632	17,742
1995	59,183,688	131,466,884	23,195,581	2,911,728	105,359,575	18,257
1996	63,329,692	140,450,107	23,108,386	3,041,116	114,300,605	18,796
1997	68,097,659	151,088,654	23,308,242	3,228,516	124,551,896	18,805
1998	70,203,147	163,670,092	23,784,977	3,596,463	136,288,652	19,313
1999	67,840,570	175,050,924	24,541,959	3,964,833	146,544,131	19,553
2000	72,436,399	183,506,472	25,232,808	4,303,498	153,970,166	19,139
2001	68,309,352	194,069,294	26,107,289	4,745,002	163,217,004	19,088
2002	72,519,831	199,597,320	26,435,677	5,075,716	168,085,927	18,938
2003	76,338,193	206,591,881	26,952,328	5,443,815	174,195,738	18,754
2004	83,485,591	215,184,233	27,109,512	5,777,881	182,296,841	19,208
2005	90,499,731	227,639,010	27,263,000	6,032,722	194,343,288	19,633
2006	96,738,320	242,971,188	27,686,188	6,347,303	208,937,698	19,933
2007	101,254,626	260,759,165	28,025,860	6,659,177	226,074,128	20,209
2008	101,921,730	278,806,393	28,301,123	7,041,011	243,464,260	20,604
2009	97,003,114	294,770,626	29,008,696	7,361,874	258,400,056	20,615
2010	105,885,644	305,725,493	29,414,230	7,816,464	268,494,799	21,858
2011	115,174,724	322,280,614	30,520,573	8,200,798	283,559,242	23,266
2012	117,625,021	342,919,500	31,408,417	8,645,444	302,865,640	23,937
2013	122,476,094	362,165,420	32,333,537	9,254,845	320,577,039	24,601

Source: TURKSTAT and author’s calculation

Appendix 2. Calculation of depreciation rates

In this study, investments are assumed to have a linear discard pattern as in the studies of OECD (1999) and Meinen et al. (1998). Accordingly, the discard process of investments can be shown by a help of cumulative distribution function as below:

Figure: Graphical Representaion of Linear Retirement Pattern of Investments



Source: OECD (1999:44)

This function display the cumulative share of scrapped capital in total capital stock with respect to time. Gradually, this share reached to 1 at the end of the period. In the cumulative distribution function (D) represented as “ax” line shown in the figure, a is the depreciation rate and x is the age of investment good. The symmetry of this function which is denoted by “1-ax” line shows the share of capital stock in operation and it is equal to “m” the service life coefficient by definition. Therefore; the share of capital stock scrapped in the age of x can be shown as below:

$D = ax$, $x = 1,2,\ldots\ldots n$ and $0 \leq D \leq 1$

the share of capital stock in operation

$Y = 1 - ax$ When the last time depreciation is known and let say it is n,

$D = an = 1$, $Y = 1 - an = 0$, hence, the depreciation rate of investment can be found as $a = 1 / n$.

Appendix 3. Cointegration Test for the Equation (4) in Table 4

It is possible to have a long-run equilibrium relationship which can be derived from one-step procedure in the form:

$$LnY_t = Ln\,A_t + \hat{a}Ln(K_t) + (1-\hat{a})Ln\,L_t + \hat{b}\,Ln\Delta K_t + \hat{e} \qquad (1)$$

where K_t is I(2) variable, while the rest of the variables are I(1). Hence, the test allows to include up to two I(2) variables and an unrestricted number of I(1) variables as explanatory variables. In order to look at the stationarity of the residual "e_t", we estimate a regression of the form

$$\hat{e_t} = a_1\hat{e}_{t-1} + \varepsilon_t \qquad (2)$$

The measurement result of equation 1 is provided in Table 1. Here, the parameter of interest is a_1. As we can see from Table 2, the null hypothesis is rejected, which means that the residual series do not contain a unit root (i.e. it is stationary). Therefore, it is possible to conclude that there is multicointegration.

Table 1: Cointegration Equation

Dependent Variable: LOG(Y)
Sample: 1981 – 2013
White heteroskedasticity-consistent standard errors & covariance

	Coefficient	Std. Error	t-Statistic	Prob.
C	3.102	0.1367	22.726	0.000
lnK_t	0.554	0.0134	39.917	0.000
lnL_t	1.766	0.5403	3.268	0.003
$ln\Delta K_t$	-0.135	0.0080	-16.981	0.000
D2001	-0.123	0.0184	-6.689	0.000
D1994	-0.116	0.0097	-11.958	0.000
D1999	3.102	0.1365	22.726	0.000

R-squared	0.993	Sum squared resid	0.037
Adjusted R-squared	0.991	Log likelihood	65.34
F-statistic	726.1	Durbin-Watson stat	1.30
Prob(F-statistic)	0.000		

Table 2: Cointegration Test

H_0: unitary root	**None**	**Intercept**
Variable	t-statistic / p-value	t-statistic / p-value
a_1	-3.981 (0.000)	-3.918 (0.005)

Note: a_1 is the parameter in the equation 1.

Appendix 4. Estimation Results with an Alternative Capital Stock

	Dependent Variable: lnY_t			
	Variable Returns to Scale		**Constant Returns to Scale**	
	K	K*	K	K*
c	4.3322*** [1.243]	4.657*** [1.304]	3.2899*** [0.1370]	3.5078*** [0.1324]
lnP_t				
lnS_t				
$ln(P_t + S_t)$				
$lnKOTH_t$				
lnK_t / lnK^*_{t-1}	0.5916*** [0.066]	0.5710*** [0.066]	0.5447*** [0.0154]	0.5216*** [0.015]
lnL_t	0.2592 [0.250]	0.2667 [0.2549]	0.4553	0.4784
D2001	-0.137*** [0.0141]	-0.1388*** [0.014]	-0.1328*** [0.0100]	-0.1336*** [0.0102]
R-squared	0.9878	0.9869	0.9875	0.9866
F-statistic	807.4	727.1	1226.5	1101.2
Prob(F-statistic)	0.000	0.000	0.000	0.000
Sum of Square Residuals	0.0676	0.0654	0.0690	0.0670
Number of observations	34	34	34	34
Wald F-statistic	1281.8	1238.5	653.6	644.7
Prob(Wald F-statistic)	0.000	0.000	0.000	0.000
HC Test: White Prob.	0.577	0.545	0.606	0.461

Note: K represents the capital stock calculated by the last year's fixed capital investments which corresponds to the results revealed in the Table 4 in the text. On the other hand, K* represents an alternative capital stock calculated by the current year's fixed capital investment and has a 0,99 correlation with the former one. As it is observed from the results, the output elasticities of the respective variables are very close to each other.

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