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PUBLIC TRANSPORTATION INVESTMENTS AND ECONOMIC GROWTH IN TURKEY†

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Abstract

This study calculates the public transportation capital stock for Turkey for the 1980-2003 period. Then those series are used to estimate the effect of public transportation investments on gross domestic product. A similar attempt is made to formulate public capital stock series for various transportation subsystems and I use them to estimate the effect of subsystem investments on the value-added (so, economic growth) of the transportation sector. Estimations indicate a positive relationship between public transportation investments and gross domestic product. At the subsystem levels, it is estimated that railway, highway, maritime, airline and pipeline investments have various effects on the value-added of the transportation sector.

Keywords: Public Transportation Investments, Economic Growth, Transportation Subsystems, Fixed Capital Stock

1. Introduction

Transportation activities have played an important role in the development of many countries. In this study, the effects of public transport investments in Turkey (and hence the developments in transport activities) on economic growth are examined.

Here, in order to be able to examine the relationship between public transport investments and economic growth, the elasticity of gross domestic product relative to the public transport capital stock is calculated. However, by calculating the elasticity of the gross domestic product with respect to the public transport capital stock, only the final effects of public transport investments on economic growth are determined. On the other hand, in order to better identify the effects of public transport investments on economic growth, it is necessary to examine the effects of public transport subsystems on economic growth. Therefore, following the calculation of the elasticity of the gross domestic product with respect to the public transport capital stock, the relationship among public transport subsystem investments and the value-added created by the transport sector is investigated as a subset of the relations between public transport investments and economic growth. Relationship among public transportation investments and value-added created by the transportation sector are also examined through the calculation of the elasticity of the value-added created by the transportation sector with respect to the capital stock in the public transport subsystems (highway, railway, airline, maritime and pipeline).

The study is organized as follows. Next section explains theoretical background. Then, data, methodology and estimation results are presented. Last section concludes the paper.

† This study is based on the author’s thesis entitled “Transportation Investment and Economic Development” presented at Gazi University in 2007.

2. Theoretical Background

The relationship between transport investments and economic growth is often explained by the relationship between public infrastructure investments, including transport investments, and economic growth. The main research topics are possible effects of public infrastructure investments on; a) the output of the private sector, sectoral output (manufacturing etc.) and total output (gross domestic product), b) the average efficiency of private sector capital stock, and c) the average labor productivity. On the other hand, apart from the growth impacts of public infrastructure investments, the *quality* of public capital can also be important. For example, according to De Oliveira (2016), government quality is the result of the accumulation of public capital. The relationship between public infrastructure investments and economic growth is examined in the context of the production function. Nevertheless, it should be noted that the relationship between transport investments and economic growth is not examined only within the framework of the production function. One of the most important examples of this is the work of Fogel (1973) on the basis of "social saving" calculations (See also Fromm, 1965; Vijverberg *et al.* 1997; Banister and Berechman, 2001; Banister and Berechman, 2003). Equation (1) shows the production function.

$$Y_t = f(A_t, K_t, L_t, G_t) \tag{1}$$

According to (1), output level (gross domestic product) (Y_t) is a function of the level of technology (A_t), the level of capital stock (K_t), the amount of labor (L_t), and the level of public infrastructure capital stock (G_t) (Mera, 1973; Da Silva Costa *et al.* 1987; Bergman and Marom, 1993; Harmatuck, 1996; Sturm *et al.* 1999; Njoh, 2000; Ghafoor and Yorucu, 2002; Herranz-Loncan, 2007). On the other hand, the production function can be defined differently, as in equation (2) (Ratner, 1983; Aschauer, 1989; Ram and Ramsey, 1989; Munnell and Cook, 1990; Tatom, 1993; Garcia-Mila *et al.* 1996; Pereira and Andraz, 2005). According to (2), private sector output ($Y_{p,t}$) is a function of level of technology (A_t), private sector productive capital stock ($K_{p,t}$), private sector employment ($L_{p,t}$) and public infrastructure capital stock (G_t).

$$Y_{p,t} = f(A_t, K_{p,t}, L_{p,t}, G_t) \tag{2}$$

Another important point is that the effects of public infrastructure investments on gross domestic product have come up with a certain lag (γ). In the case where the lag is included, the equations (1) and (2) can be expressed as in equations (1.a) and (2.a).

$$Y_t = f(A_t, K_t, L_t, G_{t-\gamma}) \tag{1.a}$$

$$Y_{p,t} = f(A_t, K_{p,t}, L_{p,t}, G_{t-\gamma}) \tag{2.a}$$

Hence, the production function of public infrastructure investments with a certain lag can be expressed as Equation (3) in the Cobb-Douglas production function form.

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} G_{t-\gamma}^{\lambda} \tag{3}$$

After taking the natural logarithm of equation (3), the estimation equation (4) can be written as follows:

$$\ln Y_t = \ln A_t + \alpha \ln K_t + \beta \ln L_t + \lambda \ln G_{t-\gamma} + \varepsilon_t \tag{4}$$

where K_t is non-residential and non-transport capital stock; G_t represents the public transportation capital stock. Besides, the estimation equation (4) includes the gross domestic product (Y_t), the total labor force (L_t) and the level of technology (A_t). In addition, (ε_t) denotes the error-term, (γ) denotes the lag value in years, (α), (β) and (λ) are the parameters to be estimated. Therefore, our main goal here is to estimate the (λ) parameter because when equation (4) is written logarithmically, the first derivative of equation (4) will give the elasticity of gross domestic product with respect to public transport capital stock (e_G), and it is represented by (λ).

$$e_G = \frac{\delta Y}{Y} \Big/ \frac{\delta G}{G} \tag{5}$$

In this study, the relationship between public transportation investments (For a detailed description of the public infrastructure see: The World Bank (1994)) and economic growth, was first examined by calculating the elasticity of gross domestic product with respect to public transportation capital stock. However, the calculation of the elasticity of the gross domestic product with respect to the public transport capital stock only ensures that the ultimate effects of public transport investments on economic growth. In order to examine the impacts of public transport investments on economic growth more clearly, it is necessary to examine the effects of public transport subsystems on economic growth.

In this study, we examine the relationship between transport and economic growth, first examining the elasticity of gross domestic product with respect to public transport capital stock, then, examining the relationship among public transport subsystems and value-added created by the transport sector.

The relationship among public transport investments and value-added created by the transport sector is explored by calculating the elasticity of the value-added created by the transport sector with respect to the public transport subsystems (highway, railway, airline, maritime and pipeline). As variables related to the private sector are not available in Turkey, we could not take the equation (2.a). In order to calculate the effects of public transport subsystem investments on the value-added created by the transportation sector, the following model is estimated first.

$$\ln V_t = b_1 + b_2 \ln H_{t-\gamma} + b_3 \ln R_{t-\gamma} + b_4 \ln A_{t-\gamma} + b_5 \ln S_{t-\gamma} + b_6 \ln P_{t-\gamma} + b_7 \ln F_t + \vartheta_t \tag{6}$$

Here, (V_t) is the total value-added created by the transport sector, (H_t) is public highway capital stock, (R_t) is public railway capital stock, (A_t) is public airline capital stock, (S_t) is public maritime capital stock, (P_t) is public pipeline capital stock, (ϑ_t) is the error-term, (b) is the parameter, and (γ) is the lag in years. The variables are expressed logarithmically so that the predicted parameters will be the elasticity values.

It is assumed that the lag values in the estimation equation (6) are the same for all subsystems. Estimation equation (6) is thus estimated assuming a lag of up to 10 years. The reason why assuming to be a lag of 10 years at most is that there has been obtained only 24 years of data set. Therefore, when the lag length is selected using the optimal lag length selection criteria such as "Akaike Information Criteria", the maximum lag length for the estimation equation (4) is 3, the optimal lag is 1, and the maximum lag length for the estimation equation (6) is 2, the optimal length is 1. When the completion period of transportation infrastructure projects is taken into consideration, the estimation results will be suspicious if only

1 year lag is taken into account. Therefore, under the constraints of the data and the number of independent variables used, it is considered appropriate to accept a lag of at most 10 years.

3. Data and Methodology

All data cover the 1980-2003 period, expressed in terms of 2000 prices and logarithmically. Total labor force data, data on labor force employed in the transport sector and value-added data (Graphs and explanations of value-added data are given in Appendix-1) are taken from the Turkish Statistical Institute [see, data for labor force (Turkstat, 2007a); see, data for value-added (Turkstat, 2007b)]. Gross Domestic Product is obtained from the electronic data distribution system of CBRT (The Central Bank of the Republic of Turkey) and realized by using the Gross Domestic Product Deflator. Total capital stock data are obtained by transforming the raw investment data in the "Annual Program" published by the State Planning Organization into capital stock after realizing it with sectoral deflators. Figures and explanatory notes on the methodology are shown in Appendix-2.

In order to get the capital stock data of each transportation subsystem, the raw public investment data of the transportation in the "Public Investment Programs" published by the State Planning Organization are obtained with the transportation sector deflator. Then the real public transport investment is converted into capital stock. The summation of capital stock data, calculated on the basis of transportation subsystems, created the public transportation capital stock series. The reason why we make such a calculation is that the transportation and communication sectors are not separated in the raw investment data in the "Annual Program" published by the State Planning Organization.

First, the stationarity of the variables is tested by obtaining augmented Dickey-Fuller (ADF) and Dickey-Fuller (DF) test statistics (see Dickey and Fuller, 1979). Following the ADF and DF tests, the model is estimated using the least squares method and the cointegration test in the framework of the two-stage Engle-Granger method in order to investigate whether there is a meaningful long-run relationship among the variables. In the two-stage Engle-Granger estimation method (Engle and Granger, 1987), the regression results are first obtained using the level values of the variables. Then, it is investigated whether the level values of error-terms obtained from the regression are stationary. Here, the critical values given in Engle and Yoo (1987) are considered. If the absolute values of the estimated values are greater than the absolute values of the critical values, the error-terms are called stationary. In the second step, the error-terms obtained from the regression are estimated by including a model in which the variables are assumed to be stationary. In the context of the sign, magnitude and significance of the coefficient of the error-term, an assessment can be made about the convergence to equilibrium.

4. Estimation Results

According to the results of the stationarity test of the estimation equation (4) (see Table 1), all the series are stationary when the first differences are taken.

Table 2 shows the parameter estimates obtained under the assumption that there is a lag between 0 and 10 years. Since the estimation equation (4) is logarithmic, it ensures that the estimated parameters are elasticity values (see Table 2).

Table 1. Summary of Stationarity Test Results for Equation 4

Variables	ADF-DF[a] t -stat. (Level) (Constant term and/or no trend)	ADF-DF[b] t -stat. (Level) (Constant term)	ADF-DF[c] t -stat. (Level) (Constant term and trend)
y_t	3.76 (0)	-1.84 (1)	-1.91 (0)
k_t	8.66 (0)	-0.88 (0)	-2.06 (0)
l_t	2.01 (0)	-1.17 (0)	-1.94 (0)
g_t	1.15 (1)	-1.72 (1)	-1.74 (2)
Variables	ADF-DF[a] t -stat. (First order difference) (Constant term and/or no trend)	ADF-DF[b] t -stat. (First order difference) (Constant term)	ADF-DF[c] t -stat. (First order difference) (Constant term and trend)
y_t	-1.05 (2)	-6.43 (0)	-6.97 (0)
k_t	-1.11 (1)	-4.16 (0)	-3.92 (0)
l_t	-4.50 (0)	-5.28 (0)	-5.32 (0)
g_t	-2.02 (0)	-2.72 (0)	-2.74 (0)

Note: The numbers in parentheses indicate the appropriate lag values. The variables expressed in lower case are logarithmic values. In addition, the null hypothesis H_0 is defined as "there is unit root".

([a])The critical values are -2.67; -1.96; -1.61 for 1%, 5% and 10% significance level, respectively.
([b])The critical values are-3.75; -3.00; -2.64 for 1%, 5% and 10% significance level, respectively.
([c])The critical values are -4.42; -3.62; 3.25 for 1%, 5% and 10% significance level, respectively.

Source: Author's own.

Table 2. Estimation Results for Equation 4

Dependent Variable: y_t											
Variables	Estimated Parameters										
	$\gamma=0$	$\gamma=1$	$\gamma=2$	$\gamma=3$	$\gamma=4$	$\gamma=5$	$\gamma=6$	$\gamma=7$	$\gamma=8$	$\gamma=9$	$\gamma=10$
k_t	-0.04 (0.85)	-0.22 (0.30)	-0.21 (0.33)	-0.06 (0.75)	0.07 (0.04)	0.17 (0.04)	0.30 (0.02)	0.09 (0.09)	0.55 (0.04)	0.44 (0.01)	0.18 (0.09)
l_t	0.86 (0.09)	0.84 (0.02)	0.99 (0.00)	0.99 (0.01)	0.98 (0.01)	0.89 (0.03)	0.74 (0.07)	0.13 (0.03)	0.48 (0.03)	0.31 (0.05	0.14 (0.05)
$g_{t-\gamma}$	0.16 (0.01)	0.19 (0.00)	0.17 (0.00)	0.14 (0.00)	0.12 (0.00)	0.10 (0.00)	0.09 (0.01)	0.07 (0.08)	0.05 (0.03)	0.08 (0.09)	0.12 (0.01)
Constant Term	10.12 (0.09)	13.49 (0.00)	11.86 (0.00)	0.02 (0.02)	7.44 (0.06)	6.52 (0.08)	5.95 (0.01)	0.31 (0.03)	4.14 (0.05)	7.67 (0.02)	13.83 (0.01)
R^2	0.98	0.99	0.98	0.98	0.97	0.97	0.96	0.96	0.96	0.95	0.95
DW	1.33	1.56	1.86	1.89	1.81	1.72	1.74	1.92	1.88	2.12	2.19

Note: The numbers in parentheses indicate probabilities. The variables expressed in lower case are logarithmic values. In addition, a maximum of 10% error level has been tested. R^2 is the coefficient of determination and DW is the Durbin-Watson test result.

Source: Author's own.

Table 3 documents the results of the first step of the two-stage Engle-Granger method. According to the parameter estimates (see Table 3), the error-terms remain stationary at the level for all lag values; there is a long-run relationship among the series for all lag values.

Table 3. Summary of Stationarity Test Results for Error-terms based on Equation 4

Error-term	ADF-DF t -stat. (Level) (Constant term and/or no trend)	PP t - stat. (Level) (Constant term and/or no trend)
$(\gamma = 0)$	-4.03 (0)	-4.03 (0)
$(\gamma = 1)$	-3.89 (0)	-3.89 (1)
$(\gamma = 2)$	-4.49 (0)	-4.55 (3)
$(\gamma = 3)$	-4.51 (1)	-4.13 (2)
$(\gamma = 4)$	-4.45 (1)	-3.82 (2)
$(\gamma = 5)$	-3.60 (0)	-3.93 (7)
$(\gamma = 6)$	-3.67 (0)	-4.01 (5)
$(\gamma = 7)$	-3.94 (0)	-4.79 (5)
$(\gamma = 8)$	-3.41 (1)	-4.13 (5)
$(\gamma = 9)$	-3.17 (1)	-5.13 (5)
$(\gamma = 10)$	-3.85 (0)	-3.97 (3)

Note: The numbers in parentheses indicate the appropriate lagvalues. In addition, the critical values given in Engle and Yoo (1987, p. 158); are -4.12 at 1% significance level, -3.29 at 5% significance level and -2.90 at 10% significance level.

Source: Author's own.

Regarding equation (4), the error-terms, which are obtained from regression by adding the lagged values of the error-term, are stationary and statistically significant for the lag values of 5, 6, 7, 8 and 9 years (see Table 4). Therefore, error-correcting mechanism is working among the series for the lag values of 5, 6, 7, 8 and 9 years. Furthermore, the negative predicted parameters for error-terms in the case of 5, 6, 7, 8 and 9 years of lag indicate that the model converges to the long-run equilibrium value as a result of a short-run imbalance (see Table 4).

Thus, as it can be understood from Table 1, Table 2, Table 3 and Table 4;there is a long-run relationship between the public transport capital stock and the gross domestic product and the model converges to the long-run equilibrium value as a result of a short-run imbalance, for the lag values of 5, 6, 7, 8 and 9 years. The estimated parameters are significant both economically and statistically for the lag values of 5, 6, 7, 8 and 9 years.

Table 4. Speed of Adaptation Results based on Equation 4

Error-term	Estimated Parameters
$(\gamma = 0)$	-0.20 (0.44)
$(\gamma = 1)$	-0.31 (0.36)
$(\gamma = 2)$	-0.28 (0.50)
$(\gamma = 3)$	-0.46 (0.18)
$(\gamma = 4)$	-0.49 (0.22)
$(\gamma = 5)$	-0.56 (0.10)
$(\gamma = 6)$	-0.61 (0.01)
$(\gamma = 7)$	-0.32 (0.04)
$(\gamma = 8)$	-0.23 (0.04)
$(\gamma = 9)$	-0.09 (0.04)
$(\gamma = 10)$	-0.05 (0.93)

Note: The numbers in parentheses indicate the probability values. In addition, a maximum of 10% error level is tested.

Source: Author's own.

According to the results of the stationarity test of the estimation equation (6) (see Table 5), r_t, a_t, s_t and p_t are stationary at the level, and h_t, v_t and f_t are stationary when the first order differences are taken. Although the process of Pesaran-Shin-Smith method (Pesaran *et al.* 2001) has to be applied in the case of such a multi-cointegration, the application is not possible due to the inadequate number of observations. However, in a model in which there are more than two variables, as in Charemza and Deadman (1997, pp. 122-127), the analysis can be continued even if the series are stationary at different levels. For this reason, the implementation of the two-stage Engle-Granger method will continue in later parts of the study.

Table 5. Summary of Stationarity Test Results for Equation 6

Variables	ADF-DF[a] t -stat. (Level) (Constant term and/or no trend)	ADF-DF[b] t -stat. (Level) (Constant term)	ADF-DF[c] t -stat. (Level) (Constant term and trend)
h_t	5.27 (0)	-1.09 (0)	-2.28 (1)
r_t	2.46 (1)	-8.84 (0)	-5.51 (3)
a_t	0.76 (1)	-2.35 (1)	-1.74 (1)
s_t	0.50 (1)	-2.94 (1)	-2.82 (1)
p_t	0.69 (1)	-4.45 (1)	-4.96 (1)
v_t	3.67 (0)	-1.18 (0)	-3.82 (0)
f_t	2.72 (0)	-1.23 (0)	-2.43 (0)
Variables	ADF-DF[a] t -stat. (First order difference) (Constant term and/or no trend)	ADF-DF[b] t -stat. (First order difference) (Constant term)	ADF-DF[c] t -stat. (First order difference) (Constant term and trend)
h_t	-1.92 (0)	-3.12 (0)	-3.15 (0)
r_t	-2.52 (1)	-7.06 (0)	-4.03 (2)
a_t	-2.75 (0)	-2.65 (0)	-4.02 (0)
s_t	-8.93 (0)	-7.58 (0)	-5.59 (0)
p_t	-1.85 (0)	-2.16 (0)	-3.05 (0)
v_t	-4.08 (0)	-6.38 (0)	-6.24 (0)
f_t	-4.35 (0)	-5.80 (0)	-5.88 (0)

Note: The numbers in parentheses indicate the appropriate lag values. The variables expressed in lower case are logarithmic values. In addition, the null hypothesis H_0 is defined as "there is unit root".

([a])The critical values are -2.67; -1.96; -1.61 for 1%, 5% and 10% significance level, respectively.
([b])The critical values are -3.75; -3.00; -2.64 for 1%, 5% and 10% significance level, respectively.
([c])The critical values are -4.42; -3.62; 3.25 for 1%, 5% and 10% significance level, respectively.

Source: Author's own.

Since the estimation equation (6) is logarithmic, it ensures that the estimated parameters are elasticity values (see Table 6). Table 6 shows the estimation results obtained under the assumption that there is a lag between 0 and 10 years, but the lags are the same for all subsystems.

Table 6. Estimation Results for Equation 6

Dependent Variable : v_t											
Variables	Estimated Parameters										
	$\gamma=0$	$\gamma=1$	$\gamma=2$	$\gamma=3$	$\gamma=4$	$\gamma=5$	$\gamma=6$	$\gamma=7$	$\gamma=8$	$\gamma=9$	$\gamma=10$
$h_{t-\gamma}$	0.13 (0.00)	0.10 (0.00)	0.01 (0.75)	-0.08 (0.09)	-0.06 (0.25)	-0.05 (0.41)	-0.02 (0.72)	0.21 (0.00)	0.17 (0.06)	0.03 (0.63)	0.07 (0.71)
$r_{t-\gamma}$	0.12 (0.17)	0.19 (0.00)	0.31 (0.00)	0.45 (0.00)	0.42 (0.00)	0.40 (0.01)	0.31 (0.01)	-0.26 (0.03)	-0.09 (0.60)	0.14 (0.18)	0.04 (0.81)
$a_{t-\gamma}$	-0.12 (0.01)	-0.15 (0.01)	-0.09 (0.18)	0.01 (0.88)	-0.01 (0.92)	0.06 (0.50)	0.18 (0.08)	0.21 (0.03)	0.09 (0.30)	0.16 (0.03)	0.00 (0.99)
$s_{t-\gamma}$	-0.003 (0.98)	-0.08 (0.02)	-0.26 (0.01)	-0.43 (0.00)	-0.41 (0.01)	-0.36 (0.03)	-0.25 (0.06)	0.31 (0.07)	0.03 (0.88)	-0.15 (0.21)	-0.20 (0.42)
$p_{t-\gamma}$	0.04 (0.47)	0.06 (0.01)	0.07 (0.14)	0.03 (0.66)	0.08 (0.32)	0.03 (0.81)	-0.10 (0.22)	-0.26 (0.00)	-0.03 (0.72)	-0.06 (0.22)	0.14 (0.05)
f_t	0.25 (0.39)	0.31 (0.03)	0.49 (0.19)	0.71 (0.09)	0.33 (0.39)	0.02 (0.96)	0.21 (0.52)	1.52 (0.00)	0.45 (0.20)	0.27 (0.43)	0.38 (0.41)
Constant Term	4.19 (0.03)	3.69 (0.03)	1.84 (0.07)	-0.62 (0.09)	4.29 (0.04)	8.05 (0.02)	5.07 (0.03)	-13.43 (0.00)	1.56 (0.07)	4.42 (0.03)	3.61 (0.05)
R^2	0.98	0.98	0.98	0.97	0.95	0.95	0.95	0.97	0.96	0.96	0.96
DW	2.05	1.86	1.79	1.73	1.50	1.80	1.43	2.16	2.46	1.90	2.24

Note: The numbers in parentheses indicate probabilities. The variables expressed in lower case are logarithmic values. In addition, a maximum of 10% error level is tested. R^2 is the coefficient of determination and DW is the Durbin-Watson test result.

Source: Author's own.

Table 7 documents the results of the first step of the two-stage Engle-Granger method. According to the parameter estimates (see Table 7), the error-terms are stationary at the level; there is a long-run relationship among the series for all lag values.

Table 7. Summary of Stationarity Test Results for Error-terms based on Equation 6

Error-term	ADF-DF t -stat. (Level) (Constant term and/or no trend)	PP t -stat. (Level) (Constant term and/or no trend)
$(\gamma=0)$	-4.40 (3)	-5.07 (2)
$(\gamma=1)$	-4.05 (2)	-4.44 (6)
$(\gamma=2)$	-4.14 (1)	-4.17 (7)
$(\gamma=3)$	-3.89 (0)	-4.02 (7)
$(\gamma=4)$	-3.76 (0)	-3.76 (0)
$(\gamma=5)$	-4.03 (0)	-4.03 (1)
$(\gamma=6)$	-3.19 (0)	-3.19 (0)
$(\gamma=7)$	-4.63 (0)	-4.57 (2)
$(\gamma=8)$	-4.82 (0)	-4.90 (2)
$(\gamma=9)$	-4.06 (3)	-3.36 (2)
$(\gamma=10)$	-3.92 (0)	-4.01 (2)

Note: The numbers in parentheses indicate the appropriate lag values. In addition, the critical values given in Engle and Yoo (1987, p. 158); are -4.12 at 1% significance level, -3.29 at 5% significance level and -2.90 at 10% significance level.

Source: Author's own.

Regarding the estimation equation (6), the error-term parameters, which are obtained as a result of the regression by adding the lagged values of the error-term, are statistically significant for the 1 year lag and 7 years lag (see Table 8). In this case, the error correcting mechanism works among the series for 1 year lag and 7 years lag. In addition, the negative estimated parameters for the error-terms in the case of 1 year lag and 7 years lag indicate that the model converges to the long-run equilibrium value as a result of an imbalance in the short-run.

Thus, as can be seen from Table 5, Table 6, Table 7 and Table 8, it has been determined that there is a long-run relationship among the variables and the model converges to the long-run equilibrium as a result of an imbalance in the short-run, for 1 year lag and 7 years lag. The estimated parameters are significant both economically and statistically for the lag values of 1 year and 7 years.

Table 8. Speed of Adaptation Results based on Equation 6

Error-term	Estimated Parameters
$(\gamma = 0)$	-0.23 (0.61)
$(\gamma = 1)$	-0.18 (0.00)
$(\gamma = 2)$	-0.34 (0.32)
$(\gamma = 3)$	0.01 (0.97)
$(\gamma = 4)$	0.13 (0.73)
$(\gamma = 5)$	0.09 (0.77)
$(\gamma = 6)$	-0.30 (0.32)
$(\gamma = 7)$	-0.65 (0.02)
$(\gamma = 8)$	0.12 (0.85)
$(\gamma = 9)$	0.48 (0.62)
$(\gamma = 10)$	0.88 (0.42)

Note: The numbers in parentheses indicate the probability values. In addition, a maximum of 10% error level has been tested.

Source: Author's own.

Thus, all relevant elasticity values calculated in our study are presented in Table 9 and Table 10.

Table 9. Elasticity of Gross Domestic Product with respect to Public Transportation Capital Stock

Lag (years)	Elasticity
5	0.10
6	0.09
7	0.07
8	0.05
9	**0.08**

Source: Author's own.

Table 10. Elasticities of Value-added of the Transportation Sector with respect to the Public Transportation Subsystem Capital

Subsystems	1 year lag	7 years lag
Highway	0.10	0.21
Railway	0.19	-0.26
Airline	-0.15	0.21
Maritime	-0.08	0.31
Pipeline	0.06	-0.26

Source: Author's own.

5. Conclusion

In this study, firstly, the effect of public transport investments on economic growth for Turkey for the period of 1980-2003 is estimated by using public transport capital stock series. This estimation is made by finding the elasticity of the gross domestic product with respect to the public transport capital stock. As a result, the elasticity of gross domestic product with respect to public transport capital stock is found to be 0.10 when considering the 5 year lag and 0.08 when the 9 year lag is taken into account (see Table 9). Accordingly, a 10% increase in the public transport capital stock leads to an increase of 0.8% when 9 years lag is taken into consideration and an increase of 0.1% when 5 years lag is taken into consideration.

In the study, the relationship among public investments in transport subsystems and the value-added created by the transport sector has been examined. For this purpose, the capital stock series have been calculated separately on the basis of transport subsystems, and thus examining the effects of public investments on transport subsystems on the value-added created by the transportation sector has been possible. As a result, it has been determined that the statistically significant effect of the public investment of transport subsystems on the value-added of the transport sector emerged with two different lags, 1 year and 7 years.

The results of the elasticities of the value-added created by the transport sector estimated by the 1 year and 7 years lag according to the capital stocks of the transport subsystems are shown in Table 10. According to the results in Table 10, it can be seen that in the short-run (1 year lag) the elasticity for public railway capital stock is positive (0.19), while the public highway capital stock have positive but lower elasticity values than railway capital stock (0.10). In the short-run, the value-added by the transport sector is positively related to the public pipeline capital stock (0.06). However, as can be seen immediately, the value of positive elasticity is low (0.06). On the other hand, the same elasticity calculations were found to be negative for short-run for public airline and maritime capital stocks [(-0.15); (-0.08), respectively].

According to the results in Table 10, the long-run (7 years lag), elasticity calculations are relatively positive and high (0.21) for public highway capital stock, whereas the same calculations for railway and pipeline capital stocks are negative and high (-0.26). In addition, it has been found that the same elasticity calculations for public maritime and airline capital stocks are (0.31) and (0.21), respectively.

The positive elasticity of the value-added created by the transportation sector with respect to the public capital stock in any transport subsystem, indicates that the net return on investment is positive. On the other hand, the fact that the same elasticity is negative means that the public investment in the subsystem, in turn, takes back more than the value-added it creates. Thus, this result is valid for railway and pipeline investments in the long-run, and for airline and maritime investments in the short-run. Regarding public railway and highway investments, the net impact of public railway investments has been positive only in the short-run while the net impact of public highway investments has been positive both in the short-run and long-run. Finally, it should be emphasized that it is necessary to produce long-run data so that the elasticity values obtained in our study will become statistically more reliable.

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Appendix-1 Value-added of the Transportation Sector in Turkey

The total real value-added created by the transport sector in Turkey during 1980-2003 period is given in Figure 1. According to Figure 1, the value-added created by the transport sector has generally increased and has risen by about 2.6 times in real terms from 1980 to 2003.

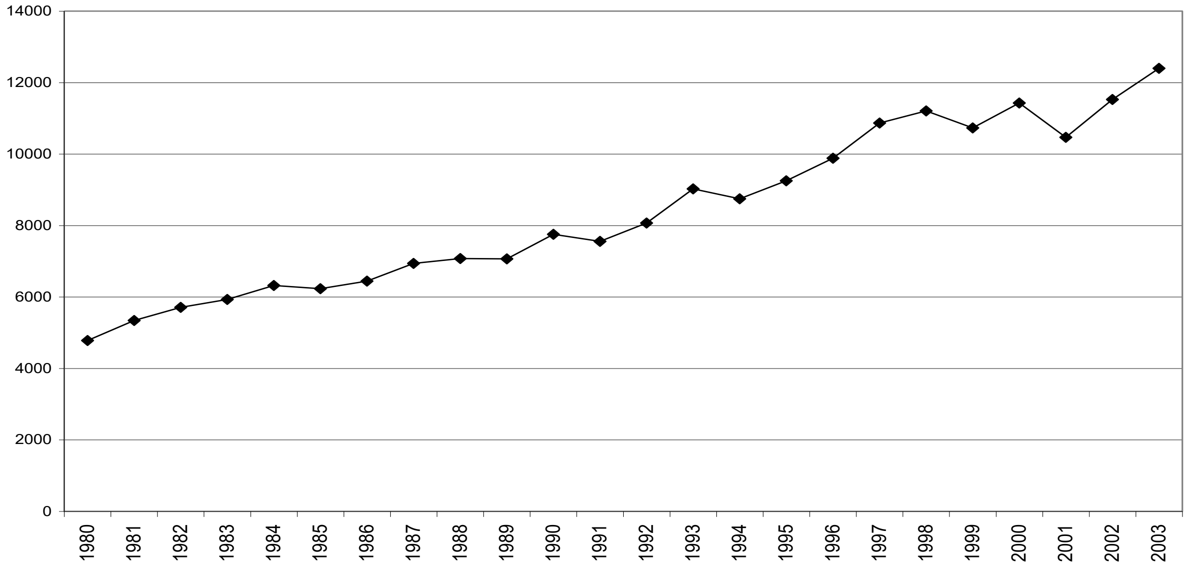

Figure 1. Total Real Value-added of Transportation Sector in Turkey (1980-2003, Prices of 2000, Million YTL)
Source: TURKSTAT (2007b)

The percentage shares of real value-added created by the transport subsystems in total real value-added are shown in Figure 2. According to Figure 2, in the period of 1980-2003, highways are at the forefront in terms of value-added created. During the 1980-2003 period, the highway subsystem made up 85% to 92% of the total real value-added created by the transport sector. The share of other subsystems in the total real value-added of the transportation sector is even less than 10% (see Figure 2). Figure 3 is given to give a clearer picture of the changes in value-added apart from highway transport subsystems.

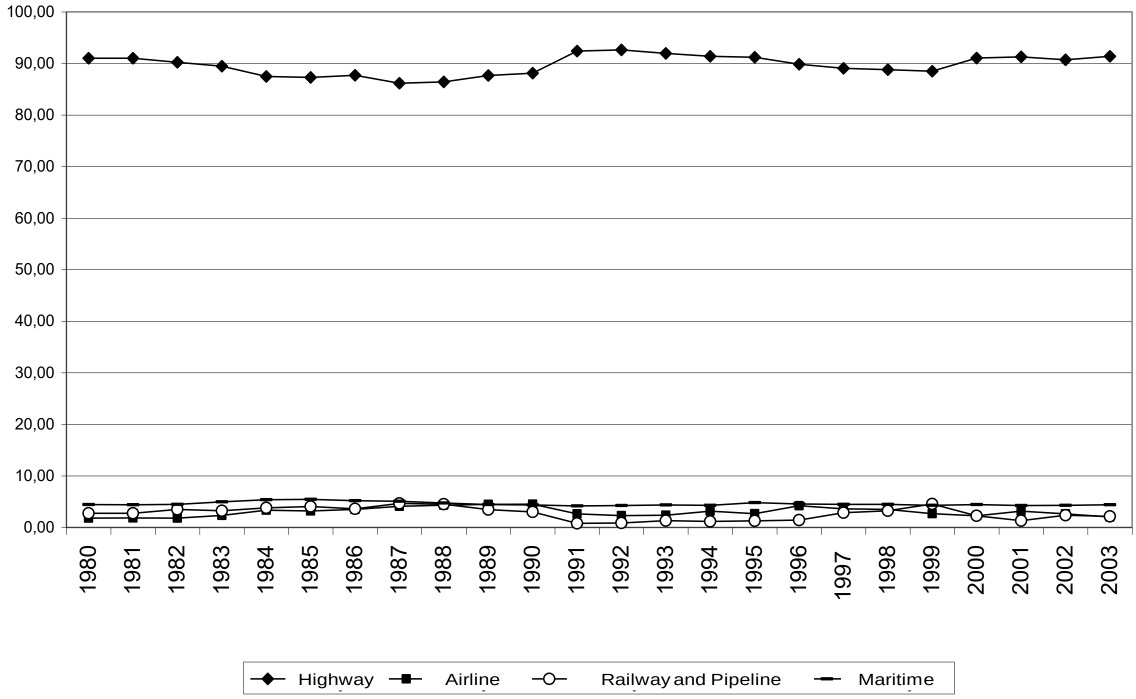

Figure 2. Distribution of Total Real Value-added in Transportation Sector in Turkey by Subsystems (1980-2003, Prices of 2000, %)

Source: TURKSTAT (2007b)

Note: Value-added of railway and pipeline in the original data obtained from TURKSTAT (2007b) have been shown together.

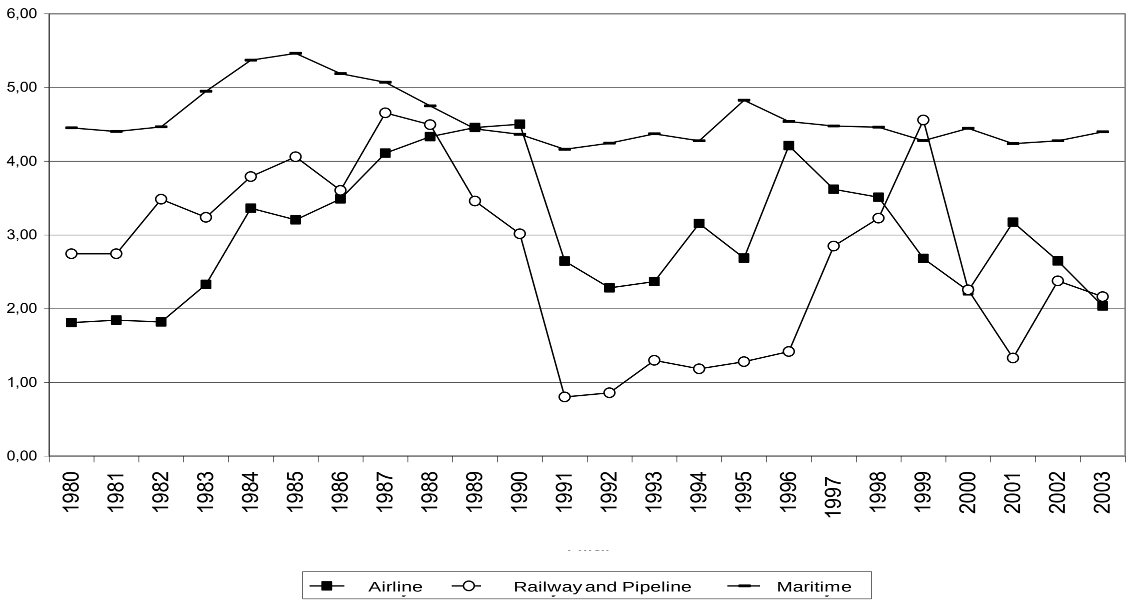

Figure 3. Distribution of Total Real Value-added in Transportation Sector in Turkey by Subsystems (Apart from Highway) (1980-2003, Prices of 2000, %)

Source: TURKSTAT (2007b).

Note: Value-added of railway and pipeline in the original data obtained from TURKSTAT (2007b) have been shown together.

Appendix-2 Public Capital in the Transport Sector in Turkey

Calculation Method

The procedure of calculation of the capital stock, which is based on Khan and Sasaki (2001), is as follows:

$$K_{it} = (1-d_i)K_{it-1} + I_{it}, \qquad t = 2,3,\ldots,n; \qquad i = 1,2,,..m \tag{7}$$

where I_{it} is investment in the sector during the period t, K_{it} is the capital stock existing in the sector i at the end of the period t; d_i shows the rate of depreciation of the capital stock in the sector i. In order to create the capital stock series, it is necessary to calculate the initial capital stock. After that, series are calculated by applying equation (7) for each year. The initial capital stock for each economic sector is calculated as follows.

$$K_0 = \frac{IK_0}{g_K + d_0^K} \tag{8}$$

$$G_0 = \frac{IG_0}{g_G + d_0^G} \tag{9}$$

where K_0 is initial private sector capital stock, G_0 is initial public sector capital stock, IK_0 is initial private sector investment, IG_0 is initial public sector investment; g_K is average annual growth rate of private sector investments, g_G is average annual growth rate of public sector investments, d_0^K is private sector initial depreciation rate, d_0^G is the public sector initial depreciation rate.

There are various debates regarding the methods of capital stock calculation, especially for the public capital stock. In this study, without considering these discussions, the capital stock was calculated simply based on the method mentioned above. [For detail, see; Bureau of Economic Analysis (1993)].

Calculation Results

The public transport capital stock data are shown in Figure 4.

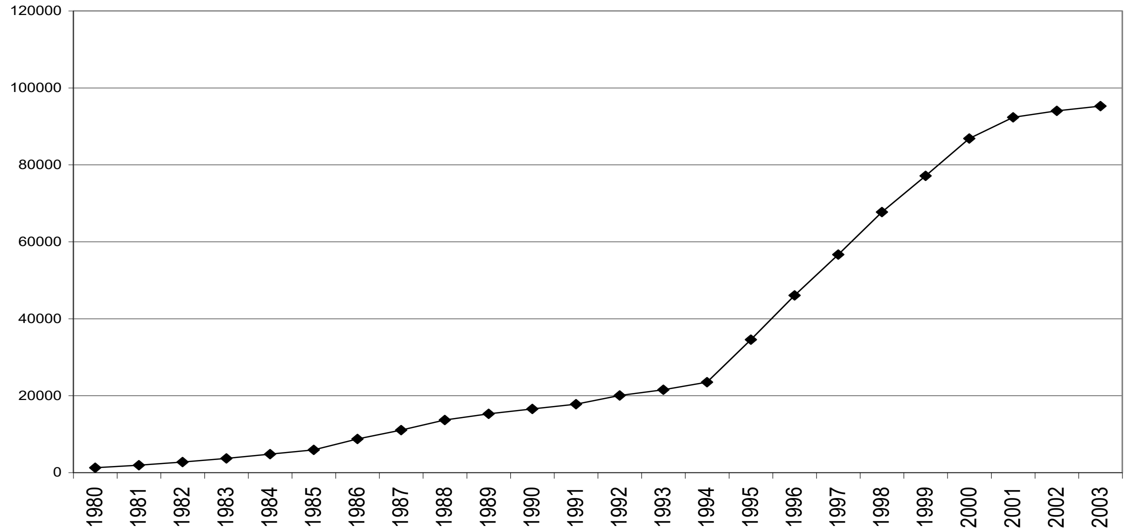

Figure 4. Public Transportation Capital Stock in Turkey (1980-2003, Prices of 2000, Million YTL)

Source: The raw investment data obtained from the "Public Investment Programs" published by the State Planning Organization (SPO, 1981; SPO, 1982; SPO, 1983; SPO, 1984; SPO, 1985; SPO, 1985b; SPO, 1987; SPO, 1988a; SPO, 1988b; SPO, 1989; SPO, 1990; SPO, 1992; SPO, 1993; SPO, 1994; SPO, 1995; SPO, 1996; SPO, 1997; SPO, 1998; SPO, 1999; SPO, 2000; SPO, 2001a; SPO, 2001b; SPO, 2002; SPO, 2003; SPO, 2004; SPO, 2005). The raw data were obtained with the transportation sector deflator and calculated by the method described in Appendix-2

The results of capital stock calculation in transport subsystems are shown in Figure 5. According to the results, since 1985, highway capital tended to increase more rapidly than other subsystems. After 1994, a significant rise has occurred in the capital stock of highways compared to other subsystems. 1994 was clearly a breaking point.

Figure 6 was shown to provide a clearer picture of the results of capital stock calculations on transport subsystems since it shows the public transport capital stock apart from highway.

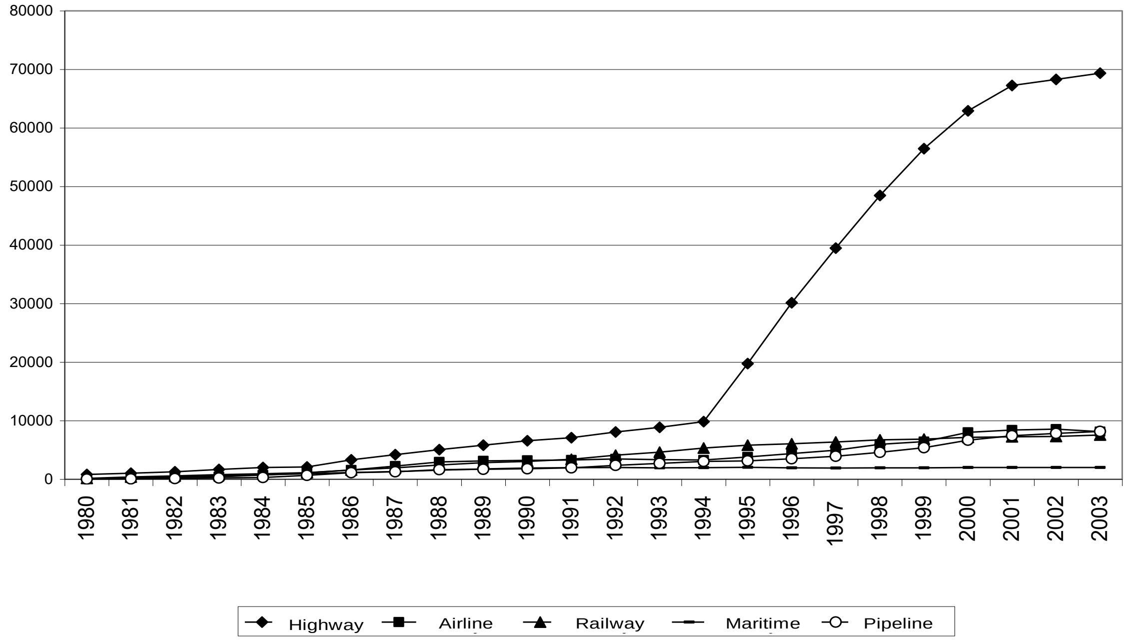

Figure 5. Public Capital Stocks in Transportation Subsystems in Turkey (1980-2003, Prices of 2000, Million YTL)

Source: The raw investment data obtained from the "Public Investment Programs" published by the State Planning Organization (SPO, 1981; SPO, 1982; SPO, 1983; SPO, 1984; SPO, 1985; SPO, 1985b; SPO, 1987; SPO, 1988a; SPO, 1988b; SPO, 1989; SPO, 1990; SPO, 1992; SPO, 1993; SPO, 1994; SPO, 1995; SPO, 1996; SPO, 1997; SPO, 1998; SPO, 1999; SPO, 2000; SPO, 2001a; SPO, 2001b; SPO, 2002; SPO, 2003; SPO, 2004;SPO, 2005)). The raw data were obtained with the transportation sector deflator and calculated by the method described in Appendix-2.

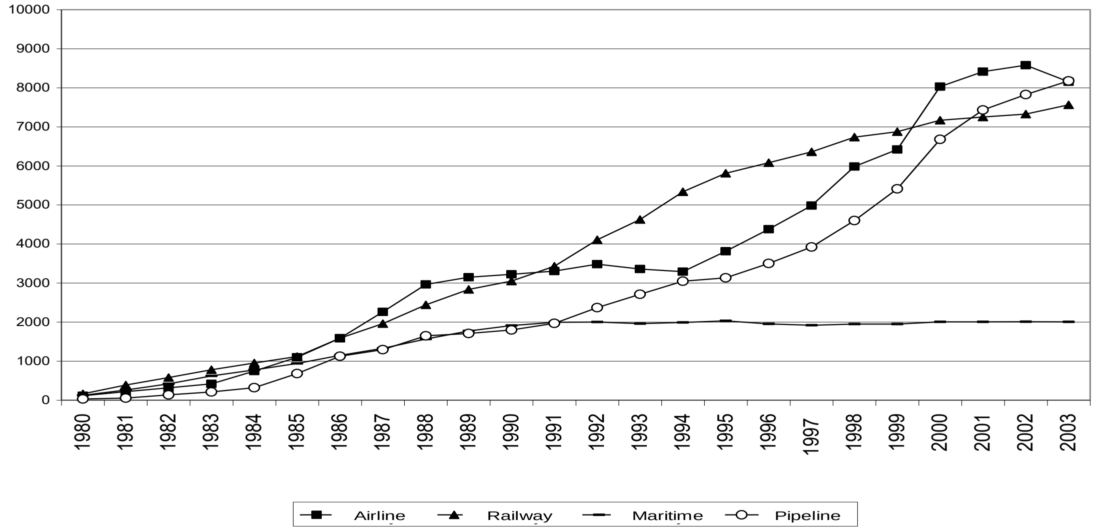

Figure 6. Public Capital Stocks in Transportation Subsystems in Turkey (Apart from Highway) (1980-2003, Prices of 2000, Million YTL)

Source: The raw investment data obtained from the "Public Investment Programs" published by the State Planning Organization (SPO, 1981; SPO, 1982; SPO, 1983; SPO, 1984; SPO, 1985; SPO, 1985b; SPO, 1987; SPO, 1988a; SPO, 1988b; SPO, 1989; SPO, 1990; SPO, 1992; SPO, 1993; SPO, 1994; SPO, 1995; SPO, 1996; SPO, 1997; SPO, 1998; SPO, 1999; SPO, 2000; SPO, 2001a; SPO, 2001b; SPO, 2002; SPO, 2003; SPO, 2004;SPO, 2005). The raw data were obtained with the transportation sector deflator and calculated by the method described in Appendix-2.