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HIGHWAY AND RAILWAY INFRASTRUCTURE, REAL INCOME AND STRUCTURAL BREAKS

Infrastructure systems affect economic development directly or indirectly depending on their structure, type, quality and quantity. Transportation infrastructure is one of the most important types of infrastructure systems since the improvements in transportation infrastructure has tangible and intangible benefits to economy such as reducing costs, increasing productivity and outputs. Therefore, investment in transportation infrastructure is important, while this contributes to economic development directly by lowering transportation costs and facilitating trade. All sectors include services provided by transport infrastructures are fundamental to economic activities due to enhanced mobility of goods and services. This reflects that the whole economy is related to transportation and the relationship between transportation infrastructure and economic growth has been analyzed in many studies by using different methodological approaches. The aim of this paper is to analyze the relationship between the transportation infrastructure and economic growth in Turkey for the period 1970-2006. Empirical analysis from cointegration tests with and without structural break show that the long run affects of real income, highway length, railway length and labor force on real income vary within tests with respect to sign and significance. However, the relationship between share of transportation in fixed capital investments and real income is positive and significant for all tests including dynamic OLS. This shows that private and public policies toward transportation infrastructure should target investments and improvements in the quality of transportation, not quantity.

Keywords*:* Highway infrastructure, Railway infrastructure, Cobb-Douglas production function, Co-integration tests, Structural breaks, Transportation investments, Jel Classification: C54, E23, H54, L92

1. INTRODUCTION

Infrastructure systems affect development directly or indirectly depending on their structure, type, quality and quantity. Transportation infrastructure is one of the most important types of infrastructure since the improvements in transportation infrastructure has tangible and intangible benefits to economy such as reducing costs, increasing productivity and outputs.

Investment in transportation infrastructure contributes to economic development directly by lowering transportation costs and facilitating trade. Services provided by transport infrastructure are fundamental to economic activities due to enhanced mobility of goods and services. Lower costs and ease of access to markets causes a range of sectoral, spatial and regional developments from the private sector point of view

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(Aschauer, 1989; Munnell, 1990; Gramlich, 1994; Bougheas, et al. 2000). Improvements in transportation cause increased accessibility, specialization and market expansion thus causing increasing returns to scale and spatial agglomeration effects as well as innovation. As a result, total factor productivity and GDP growth increases (Bougheas et al., 2000; Lakshmanan, 2007). The effects of transportation infrastructure to economic development are argued to be more interpretable in developing countries rather than developed countries (Zhou, Yang, Xu and Liu, 2007).

The aim of this paper is to analyze the relationship between the transportation infrastructure and economic growth in Turkey for the period 1970-2006. Empirical analysis is carried through time series analysis; cointegration tests with and without structural breaks.

The rest of the paper is organized as follows: the second section provides the literature survey, while the third section consists of data and methodology and the fourth section shows the empirical results. The last part concludes the paper with interpretation of the findings and policy implications.

2. LITERATURE SURVEY

The relationship between transportation infrastructure and economic growth has been analyzed in many studies for regions, countries and continents by using production function or cost function approaches. The theoretical framework which argues that improvements in transportation infrastructure has positive effects on economic development, is supported with many empirical studies where transportation infrastructure is measured by highway lengths, railway lengths, transportation spending per capita and transportation capital such as water and sewer, electricity and gas, hospitals and passenger rail stations. These measures are selected according to the observed area (local, county or national). The improvement measures regarding economic development are generally per capita income, growth, investments (e. g. foreign direct investment, manufacturing industry), manufacturing costs, productivity, and rate of return, output, employment, and labor force. The evidence from empirical studies shows, in general, a positive relationship between transportation with all its components (investment, infrastructure) and development (productivity, economic growth, quality). There is a vast amount of literature on the relationship between transportation infrastructure and economic development. Therefore, Table A1 shows some selected studies with respect to infrastructure and development measures, observed area, period and results, while these studies are briefly summarized below.

Most of the research dealing with the economic effect of transport infrastructures has relied on the estimation of aggregated Cobb-Douglas production function. The initial novelty of including public capital as an input, along with labor and private capital, put aside many of the econometric problems that had been identified in the estimation of production functions, both at the firm level or on the aggregate. Therefore, in the first generation of studies on the effect of public infrastructure, the specification commonly used is a Cobb-Douglas production function estimated by OLS, despite the well-known econometric problems posed by this type of production function estimation (Griliches and Mairesse, 1998).

Production function approach has been first used by the most known researcher of that topic, Aschauer, also the pioneer of the relationship between infrastructure and development. Aschauer (1989) investigates the effects of public capital on the productivity of private sector. The results indicate that the elasticity of private sector productivity with respect to public capital is positive. Munnell (1990) also finds a positive (elasticity of 0.35) relationship between transportation investment and private sector productivity. Munnell and Cook (1990) investigate the impact of highways on Gross State Product (GSP) where they show that the elasticity of GSP with respect to highways 0.06 on the positive side. Duffy-Deno and Eberts (1991), Eisner (1991), Garcia-Mila and McGuire (1992) and Moonmaw, et al. (1994) similarly obtain positive relationships between transport infrastructure and per capita income by using production function approach.

Jones (1990), Mofidi and Stone (1990) and Reynolds and Maki (1990) study the effects of highway spending per capita on three different development measures. Jones et al (1990) consider employment, income and investment whereas Mofidi and Stone (1990) takes manufacturing investments and employment into account and Reynolds and Maki (1990) investigate new manufacturing plants. First two studies' results are positive but the latter one's result is neutral. Singletary, et al. (1995), Grihfield and Panggabean (1995), Garcia-Mila, McGuire and Porter (1996) and Fernald (1999) show that increases in highways raise manufacturing industry employment and productivity growth.

Berndt and Hansson (1992), Lynde and Richmond (1993), Seitz (1993), Nadiri and Mamuneas (1994), Conrad and Seitz (1994) and Boarnet (1996; 1998) use cost function approach for the investigation of the relationship between transport measures and development for Sweden, United Kingdom, West Germany and USA. The common finding of these studies is that the effects of transport measures are cost reducing elements.

Bougheas, Demetriades and Mamuneas (2000) also introduce infrastructure as a cost reducing technology in their cross country study and according to their approach, transportation infrastructure cause specialization and long run growth. Infrastructure as a technology which reduces costs in the production of intermediate inputs has more impact rather than as an input in the production of final goods. Bougheas, et al. (2000) argue that variation across countries is an important criterion due to the lack of infrastructure in less developed countries and abundance of infrastructure in developed countries.

Boopen (2006) and Zhou, Yang, Xu and Liu (2007) examine the growth impact of transportation capital for developing countries of Africa and China, respectively. The former study uses a Cobb Douglass production function which regress total output on labor, physical capital and transportation capital. The findings show that investment in transportation capital is more productive than investment on average in Africa. The second paper investigates China with regional perspective. The correlation matrix for highways, growth and exports shows that highway construction has significant and positive effect on economic growth. The study also stresses that the quality and the quantity of transportation infrastructure is crucial in terms of its contribution to economic development.

3. DATA AND METHODOLOGY

The data set for the analysis consists of three parts. The first part is infrastructure data (highway lengths in km, railway lengths in km, share of transport in fixed capital investment) which is obtained from the Canning database[1] and Turkish State Railways and General Directorate of Highways. The second part, labor data (labor force) and the third part, economic measurement data, (real GDP per capita), are obtained from OECD database[2]. All of the data is annual and covers the period 1970-2006.

In the light of the literature on the relationship between infrastructure and economic growth, a Cobb-Douglass production function model is used as the econometric model for this analysis:

$$GDP_t = A_t \cdot HW_t^{\beta_1} \cdot RR_t^{\beta_2} \cdot LF_t^{\beta_3} \cdot TS_t^{\beta_4} \cdot U_t \quad (1)$$

where GDP is the per capita GDP, A is total factor productivity, HW is the highway lengths in km, RRW is railway lengths in km, LF is the labor force, TS is the transportation share in fixed capital investment and U is the error term of the regression equation. To estimate and interpret the coefficients β_1, β_2, β_3 and β_4, the natural logarithms of both sides of the model is taken to get.

$$lgdp_t = a_t + \beta_1 lhw_t + \beta_2 lrr_t + \beta_3 llf_t + \beta_4 lts_t + u_t \quad (2)$$

In line with the theory, we expect β_1, β_2, and β_4 to be positive. Increases in highways and railways in length and investment in transportation help the cost of production to fall and lead to a rise in output. β_3 could be positive or negative depending on the productivity of the labor force which depends on many factors such as education, human capital etc.

Time series analysis requires that the variables are stationary or not. For example, for cointegration tests the variables should be non-stationary and integrated of the same order because the tests may falsely give evidence of cointegration if one or more of the variables are stationary. The time series properties of the variables are determined by the use of ADF (Augmented Dickey-Fuller), Phillips-Perron and KPSS unit root tests. We use these three different tests to check the robustness of the results. ADF is more efficient in large samples whereas KPSS is in small samples. KPSS and ADF tests should support each other, if the fractional stationarity does not exist. The rejection frequency of the ADF test falls dramatically in the presence of a break in the cointegration vector (Gregory and Hansen, 1996b). In addition, auto-regressive process is suitable for ADF but moving average process fits Philips- Perron (PP) unit root test.

After the unit root tests, we conduct the Engle-Granger two-step cointegration test which does not take structural breaks into account. The Engle-Granger test applies ADF unit root test on the residuals of the equation with variables that are integrated of the same order. If the residuals are stationary, then the variables in question are cointegrated. Johansen-Juselius cointegration test is also performed to compare and add a new

[1] http://www.hsph.harvard.edu/faculty/david-canning/

dimension to the results of Engle-Granger two-step cointegration test. Johansen-Juselius approach provide the possibility of multiple cointegration relationships. This test offers trace and maximum Eigen-value statistics for the rejection of the hypotheses.

As the data covers 37 years, the existence of structural breaks should also be investigated to make the analysis more robust. The Zivot-Andrews unit root test takes the structural breaks into account endogenously. This unit-root test has three models, which are shown below:

$$Model\ A: y_t = \hat{\mu}^A + \hat{\theta}^A DU_t(\lambda) + \hat{\beta}_t^A + \hat{\alpha}^A y_{t-1} + \sum_{j=1}^{k} \hat{c}^A \Delta y_{t-j} + \hat{e}_t \quad (3)$$

$$Model\ B: y_t = \hat{\mu}^B + \hat{\gamma}^B DT_t(\lambda) + \hat{\beta}_t^B + \hat{\alpha}^B y_{t-1} + \sum_{j=1}^{k} \hat{c}^B \Delta y_{t-j} + \hat{e}_t \quad (4)$$

$$Model\ C: y_t = \hat{\mu}^C + \hat{\theta}^C DU_t(\lambda) + \hat{\gamma}^C DT_t(\lambda) + \hat{\beta}_t^C + \hat{\alpha}^C y_{t-1} + \sum_{j=1}^{k} \hat{c}^C \Delta y_{t-j} + \hat{e}_t \quad (5)$$

Zivot-Andrews actually follow the Perron’s ADF testing strategy and use during testing the unit root regression equations. Their three model unit root testing differs with the exception of DT_B is to increase in absolute value the magnitude of the t statistic for testing $\alpha^i = 1$. According to model A for a one time change in the level of the series, which is called crash model by Perron, this model detects the mean break, i.e the change in the intercept of the trend function at break time. Model B covers the change in the slope of the trend function occurring at break time, which is called changing growth by Perron, detecting the slope break. The last model C detects changes in both mean and slope at the break time. In these models, DU and DT are dummy variables that respectively capture a break in mean and slope occurring at the break time. The break point is TB where $DU = 1$ if $t > TB$, and zero otherwise. DT is equal to $(t - TB)$, if $(t > TB)$ and zero otherwise. The null hypothesis is rejected if the coefficient is statistically significant. Each model is estimated by ordinary least squares (OLS) with the break fraction $\lambda = {}^{TB}/_{T}$. For each value of λ, the number of extra regressors, k is determined using the model selection criterions and the t-statistics for testing $\alpha = 1$ is computed.

Based on the results of this test, the long run relationship between the relevant variables is tested by the Gregory-Hansen cointegration test. The null hypothesis of Gregory-Hansen cointegration test is similar to the Engle-Granger test and the effect of an unknown structural break year is included by three types of models which are; shift in intercept (model C as level shift), shift in trend (model C/T as level shift with trend) and both trend and intercept shifts (model C/S as a regime shift).

Standard cointegration model with trend and no structural break can be shown as:

$$y_{1t} = \mu + \beta_t + \alpha^T y_{2t} + e_t\ where\ t = 1, \dots, n; y_{2t}\ is\ I(1) and\ e_t\ is\ I(0) \quad (6)$$

The motivation for this test is that there may be occasions in which the researcher may wish to test that cointegration holds over some (fairly long) period of time, but then shifts to a new 'long-run' relationship (Gregory and Hansen, 1996b). Gregory and Hansen treat the timing of this shift as unknown. The general kind of structural change considered in Gregory and Hansen (1996a) permits changes in the intercept μ and/or changes to the slope coefficients α but not the trend coefficient β.

To model the structural change, they define the dummy variable;

$$\varphi_{t\tau} = 0, if\ t \leq [n\tau] \tag{7}$$

$$\varphi_{t\tau} = 1, if\ t > [n\tau] \tag{8}$$

where the unknown parameter $\tau\epsilon(0,1)$ denotes the (relative) timing of the change point, and [] denotes integer part. The level, level shift with trend and regime shift alternatives are:

$$Model\ C: y_{1t} = \mu_1 + \mu_2\varphi_{1\tau} + \alpha^T y_{2t} + e_t \tag{9}$$

$$Model\ {}^{C}/_{S}: y_{1t} = \mu_1 + \mu_2\varphi_{1\tau} + \beta_t + \alpha_1{}^T y_{2t} + \alpha_2{}^T y_{2t}\varphi_{t\tau} + e_t \tag{10}$$

$$Model\ {}^{C}/_{T}: y_{1t} = \mu_1 + \mu_2\varphi_{1\tau} + \beta_1 t + \beta_2 t\varphi_{t\tau} + \alpha_1{}^T y_{2t} + \alpha_2{}^T y_{2t}\varphi_{t\tau} + e_t \tag{11}$$

In this case μ_1 , α_1 and β_1 are the intercept, slope coefficients and trend coefficient respectively before the regime shift and μ_2 , α_2 and β_2 are the corresponding coefficients changes after the break. For each τ, the above models are estimated by OLS, yielding the residuals e_t. From these residuals, the ADF test statistics and the Phillips' (1987) test statistics $Z_\alpha(\tau), Z_t(\tau)$ are estimated. $Z_\alpha(\tau)\ or\ Z_t(\tau)$ statistics are acquired at the breaking point where the minimum ADF is found. Next, the null hypothesis of no co-integration is tested by using the smallest values of these statistics in the possible presence of breaks.

After Gregory-Hansen cointegration test, break years are used to estimate the coefficients by Stock-Watson (1993) Dynamic OLS model:

$$X_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 D1_t + \alpha_3(D2_t Y_t) + \alpha_4 \Delta Y_{t-1} + \alpha_5 \Delta Y_{t+1} + u_t \tag{12}$$

The dummy variables D1 and D2 are determined according to the break years. As there are four independent variables in this study, the Stock-Watson Dynamic OLS model becomes:

$$gdp_t = \alpha_0 + \alpha_1 hw_t + \alpha_2 D1_t + \alpha_3 (D2_t hw_t) + \alpha_4 \Delta hw_{t-1} + \alpha_5 \Delta hw_{t+1} + \alpha_6 rr_t + \alpha_7 (D3_t rr_t) + \alpha_8 \Delta rr_{t-1} + \alpha_9 \Delta rr_{t+1} + \alpha_{10} lf_t + \alpha_{11} (D4_t lf_t) + \alpha_{12} \Delta lf_{t-1} + \alpha_{13} \Delta lf_{t+1} + \alpha_{14} ts_t + \alpha_{15} (D5_t ts_t) + \alpha_{16} \Delta ts_{t-1} + \alpha_{17} \Delta ts_{t+1} + u_t \tag{13}$$

4. EMPIRICAL RESULTS

4.1. Unit Root and Cointegration Testing without Structural Break

The results of unit root test (ADF, PP, and KPSS) are shown in Table 1. According to the ADF and PP tests, all of the variables have one unit root (i.e. integrated of order one, I (1)), but KPSS test signals that the effect of structural breaks should be examined. For the analysis without structural breaks, we conclude that all variables are I (1).

Table 1: Unit-Root Tests

Unit Root Test	*lgdp*	*lhw*	*lrr*	*llf*	*Lts*
ADF	-2,78**	0,01**	-1,99**	-1,86**	-2,39**
PP	-20,15	-0,74**	-2,02**	-1,63**	-2,28**
KPSS	0,72**	0,45*	0,69**	0,72**	0,71**

Note: *, **, and *** indicate the rejection of null hypothesis as stationary at 10%, 5% and 1% significance levels, respectively.

The long run relationship between real GDP per capita, transportation measures and labor force is tested with Engle-Granger (1987) two step modeling where the results are shown in Table 2. According to the first step, the ADF test for the residuals (unit root test) signals that the null hypothesis that the residuals have a unit root is rejected. This means that there is no long run relationship between the variables. The possibility of spurious results is ruled out as R-squared is less than the Cointegration Regression Durbin Watson (CRDW). The possibility of cointegration in the long run increases when CRDW is greater than R-squared.

The second step is the error correction mechanism (ECM), where the first differences of the variables and the residuals in period t-1 are included in the estimation. The magnitude of the residual e_{t-1} is the derivation from long-run equilibrium in period (t-1). The coefficient of residuals in period (t-1) is found to be -0,132, which indicates that the ECM is working and there is a short run relationship between the variables. All of the independent variables have positive coefficients with only the share of transport in fixed capital investment being statistically significant.

Table 2: Engle-Granger 2-Step Cointegration Test

1st Step	**Regressor**	**Coefficient**	**T-Stat**
	Constant	-12,146	-0,753
	lrr	4,227	3,277***
	lhw	3,918	1,848*
	llf	3,071	11,443***
	lts	0,327	2,938***
	R^2 = 0,984 and CRDW = 1,144		
2nd Step	**Regressor**	**Coefficient**	**T-Stat**
	Constant	0,054	5,143***
	dlrr	0,553	0,574
	dlhw	0,379	0,339
	dllf	0,272	0,601
	dlts	0,224	3,511***
	res(-1)	-0,132	1,231
	ADF: -3,72		

Note: *, **, and *** indicate the rejection of null hypothesis at 10%, 5% and 1% significance levels, respectively. Critical values are based on MacKinnon (1991) and at 5% significance level are -4.413; models include constant and no trend; *k* is the lag length used in the test for each series and number of lags are determined according to the AIC and given in parenthesis.

After determining the appropriate lag length by Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC), Johansen-Juselius cointegration procedure is applied on the variables. Table 3 below reports the results of this test.

Table 3: Johansen-Juselius Cointegration Test

Trace Test		
Null	**Alternative**	**Stat**
r = 0	r ≥ 1	135,090***
r ≤ 1	r ≥ 2	79,126***
r ≤ 2	r ≥ 3	44,995**
Maximum Eigen-value Test		
Null	**Alternative**	**Stat**
r = 0	r ≥ 1	55,964***
r ≤ 1	r ≥ 2	34,131**
r ≤ 2	r ≥ 3	26,245**

Note: *, **, and *** indicate the rejection of null hypothesis at 10%, 5% and 1% significance levels, respectively. List of the variables included in the cointegrated vector is $lgdp, lhw, lrr, lts$ and intercept; and 37 observations from 1970 to 2006.

Maximum Eigen-value and trace test statistics reject the null hypothesis of no cointegration at all significance levels. Johansen-Juselius cointegration procedure suggests three cointegrating vectors at 5% and 10%. However, maximum eigenvalue test indicates only one vector at 1%. This long run relationship normalized for $lgdp$ is estimated as:

$$lgdp = 19{,}591(lhw) - 51{,}239(lrr) + 3{,}174(llf) + 3{,}35(lts)$$

(4.333) (-6.903) (1.252) (7.686)

The t-values in parentheses show that except railway length all of the variables affect real GDP per capita positively, with the exception of the coefficient of labor force being statistically insignificant.

4.2. Unit Root and Cointegration testing with Structural Break

To investigate the possibility of structural breaks, Zivot and Andrews (1992) test is applied over the period 1970-2006. The results presented in Table 4, reporting the minimum t statistics and their corresponding break times, confirm the results of the previous tests that all series are I(1). Break points coincide with the Military Coup years; 1980 for GDP per capita and 1982 for highways. For railways, labor force and transportation share in fixed capital investment; break points are 1988, 1993 and 1994, respectively which seem to coincide with the economic crisis.

Table 4: Zivot-Andrews Unit Root Test

	lgdp	*lhw*	*lrr*	*llf*	*Lts*
Break Year	1980	1982	1988	1993	1994
Y (t-1)	-0,39 (-3,14)	-0,61 (-4,43)	-0,58 (-3,76)	-0,84 (-4,61)	-1,28** (-5,05)
t	0,04 (2,72)	0,001 (1,72)	0,001 (2,56)	0,014 (4,65)	0,028 (4,64)
B(t)	-0,08 (-1,61)	0,036*** (6,45)	0,003 (0,49)	-0,08*** (-5,56)	-0,49** (-5,12)
D(t)	0,03 (0,99)	-0,02 (-4,79)	-0,01 (-1,67)	0,04 (3,11)	-0,01 (-0,07)
DT(t)	-0,02 (-2,25)	0,001 (1,59)	0,0001 (0,2)	-0,005 (-4,34)	-0,015 (-1,93)
k	0	0	0	4	4

Note: *, **, and *** indicate the rejection of null hypothesis at 10%, 5% and 1% significance levels, respectively. Critical values at 1%, 5% and 10% significance level are –5.57, -5.08 and –4.82 respectively (Zivot and Andrews, 1992), k is the lag length used in the test for each series and selected criteria based on AIC, t statistics of the related coefficients are given in parenthesis.

Gregory and Hansen (1996) extended the Engle-Granger cointegration test to allow for breaks in either just the intercept or both the intercept and trend of the cointegrating relationship at an unknown time. As stated by Gregory and Hansen (1996), their testing procedure is of special value when the null hypothesis of no cointegration is not rejected by the conventional tests. The results of this test (Table 5) shows that for all models there is evidence of a cointegration with the exception the results of Z_{α}^{*}.

Table 5: Gregory-Hansen Cointegration test

Model	ADF	Break Year	Z_t^*	Break Year	Z_α^*	Break Year
C	-7,911***	1982	-14,596***	1985	-59,221	1997
C/T	-8,777***	1994	-16,117***	1994	-59,255	1981
C/S	-8,043***	1987	-14,491***	1985	-59,251	1998
Critical Value	-6,840				-88,471	

Note: *, **, and *** indicate the rejection of null hypothesis at 10%, 5% and 1% significance levels, respectively. Critical values for ADF and Z_t at 5% significance level is -6.84, and for Z_α is -88.47 respectively (Gregory and Hansen, 1996).

We then proceed to Stock and Watson Dynamic OLS model shown in (13) to estimate the coefficients of cointegrated variables. The estimation results are presented in Table 6. It can be seen that highway length and labor force has a negative and significant relationship with income while railway length affects it positively but the coefficient is not statistically significant. The coefficient of the share of transportation in fixed capital investment is both positive and significant as expected.

Table 6: Stock-Watson Dynamic OLS model

	α_1	α_3	α_6	α_7	α_{10}	α_{11}	α_{14}	α_{15}
Coeff.	-2,38	5,75	0,397	-12,96	-0,27	1,37	0,29	-0,12
T-stat	-2,184**	1,413	0,303	-3,965***	-0,570	1,827*	3,286***	-0,787

Note: The numbers in parentheses are the t-statistics for the. *, ** and *** denotes the rejection of null that the corresponding coefficients are zero at 10%, 5% and 1% significance levels respectively. Dummy variables are as follows $D1_t$ is 0 up to 1982 and 1 thereafter, and $D2_t$, $D3_t$, $D4_t$ and $D5_t$ are 0 up to 1994 and 1 thereafter.

4.3. Overall Results

When the empirical results from cointegration analysis without and with a structural break are considered, we see that the effects of highway length, railway length and labor force on real GDP per capita are contradictory. The results are summarized in Table 7. The effect of share of transportation in fixed capital investment is positive and significant all through.

Table 7: Overall results

Variables	Cointegration Test Without Structural Break		Cointegration Test With Structural Break
	Engle-Granger Test	Johansen Test	Stock-Watson DOLS Model
Highway length	+	+*	-*
Railway length	+	-*	+
Labor force	+	+	-
Share of transportation in fixed capital investment	+*	+*	+*

* indicates statistical significance.

5. CONCLUSION

This paper analyzes the relationship between the transportation infrastructure and economic growth in Turkey for the period 1970-2006. In order to determine the features of this relationship, cointegration tests with and without structural breaks are applied through time series dimension. The results obtained rom Engle-Granger, Johansen-Juselius, Gregory-Hansen and Stock-Watson procedures show that while the effects of highway length, railway length and labor force on real income per capita vary across tests with respect to sign and statistical significance, the effect of *share of transportation in fixed capital investment* is positive and significant for all tests.

These results can be interpreted as follows. The amount and type of investment in transportation rather than length of infrastructure (highways and railways), is crucial for increasing real GDP per capita. As an example, public investment on highway infrastructure in Turkey was on average 2.36 % of the government budget for 1970-2005. Highway length in kilometers increased from 59,000 kms in 1970 to 61,000 kms in 2005 (Kuştepeli, Gülcan, Akgüngör, 2008). The effects of transportation on real economic activities in manufacturing and service based sectors have visible benefits such as time consumption in shipping of both raw materials, semi-finished goods and produced goods. In that sense, private and public policies toward transportation infrastructure should target investments and improvements in the quality and quantity of transportation.

More generally, the results indicate that there is a (positive) relationship between the transportation infrastructure and real GDP per capita. Models designed to assess this relationship should be formed in a scrutinized manner in terms of economic theory, econometric and empirical tools.

Future research should be directed at explaining transportation infrastructure effects on different measures more directly related to up-to-date issues such as innovation performance, social network analysis, and online economic activities. Regional and national properties such as geographical characteristics, information systems play an important role and thus should be taken into account. Applying econometric methodology with cross-section dimension could supply more comparable results for policy implications; however this would only be possible whenever statistical institutions produce consistent time series data across countries.

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Supplementary bibliography is given in table A1.

INFRASTRUKTURA DROGOWA I KOLEJOWA, DOCHÓD REALNY I ZMIANY STRUKTURALNE

Systemy infrastruktury wpływają na rozwój gospodarczy bezpośrednio lub pośrednio, w zależności od ich struktury, rodzaju, jakości i ilości. Infrastruktura transportowa jest jednym z najważniejszych typów systemów infrastrukturalnych, gdyż jej poprawa przynosi zarówno materialne i niematerialne korzyści dla gospodarki, takie jak obniżenie kosztów, jak również zwiększenie wydajności. Dlatego inwestycje w infrastrukturę transportu są ważne, a to przyczynia się do rozwoju gospodarczego, bezpośrednio poprzez obniżenie kosztów transportu oraz ułatwienie handlu. Wszystkie sektory usługi świadczonych przez infrastrukturę transportową są podstawą działalności gospodarczej ze względu na zwiększoną mobilność towarów i usług. Zatem cała gospodarka jest związana z transportem, a relacja pomiędzy infrastrukturą transportową i wzrostem gospodarczym została przeanalizowana w wielu badaniach za pomocą różnych podejść metodologicznych. Celem tej publikacji jest analiza zależności występujących między infrastrukturą transportu a wzrostem gospodarczym w Turcji na przestrzeni lat 1970-2006. Analiza empiryczna przeprowadzona w oparciu o testy adaptacyjne uwzględniająca zarówno zmiany strukturalne jak i ich brak dowodzi, iż na dłuższą metę wpływ realnego dochodu, długości dróg publicznych, linii kolejowych i siły roboczej w kontekście rzeczywistych dochodów zmienia się w obrębie różnych testów w zależności od rodzaju wskaźników i ich znaczenia. Jednakże, zależność pomiędzy udziałem transportu w ustalonych inwestycjach kapitałowych a dochodem realnym jest korzystna i znacząca dla wszystkich wspomnianych testów. Wynika z tego, że zarówno prywatny jak i publiczny sektor infrastruktury transportu powinien obierać za główny cel inwestycje oraz poprawę jakości przewozu a nie jego ilość.

Słowa kluczowe: Infrastruktura drogowa, infrastruktura kolejowa, funkcja Cobb-Douglasa, testy kointegracyjne, zmiany strukturalne, inwestycje transportowe, klasyfikacje Jel: C54, E23, H54, L92

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Table A1. Literature Review

Author and Year	Infrastructure Measure	Development Measure	Area, Period and Model	Results
Deno, 1988	Highway capital	Output	USA, Production Function	+
Aschauer, 1989	Transportation, water and sewer, gas and electricity	Productivity of private sector	USA, 1949-1985	+
Aschauer, 1990	Highway miles	Income per-capita	USA, 1960-1985, Production Function	+
Munnell, 1990	Transportation, water and sewer, gas and electricity	Productivity of private sector	USA, 1949-1987	+
Munnell and Cook, 1990	Highways	Gross State Product (GSP)	USA, 1970-1986, Production Function	+
Jones, 1990	Highway spending per-capita	Employment, income and Investment	USA	+
Mofidi and Stone, 1990	Highway spending per-capita	Manufacturing investment and employment	USA	+
Reynolds and Maki, 1990	Highway spending per-capita	New manufacturing plants	Labor market areas	No effect
Duffy-Deno and Eberts, 1991	Transportation, water and sewer, public hospitals	Income per-capita	Twenty-eight metros, 1980-1984	+
Eisner, 1991	All state and local public capital	GSP	USA, 1970-1986	+
Hulten and Schwab, 1991	Highways	Manufacturing output	Nine regions, 17 years	No effect
Coughlin, Terza and Aromdee, 1991	Highway miles per square mile	Foreign Direct Investment (FDI)	USA	+

Author and Year	Infrastructure Measure	Development Measure	Area, Period and Model	Results
Garcia-Mila and McGuire, 1992	Highway miles per square mile	GSP	USA, 1970-1982, Production Function	+
Berndt and Hansson, 1992	Transportation, water and sewer, electricity	Private sector costs	Sweden, 1964-1988	-
Tatom, 1993	All public capital	Private sector productivity	USA, 1949-1990	No effect
Lynde and Richmond, 1993	Nonresidential public capital	Manufacturing costs and productivity	UK, 1966-1990	+
Seitz, 1993	Highways	Manufacturing costs and productivity	West Germany, 1970-1989	+
Nadiri and Mamuneas, 1994	All public capital	Manufacturing costs, labor demand	Twelve Manufacturing industries, 1955-1986	+
Luce, 1994	Highway and railroad access	Employment, labor force	Local governments	+
Evans and Karras, 1994	Highways and highway spending	GSP	USA, 1970-1986	No effect
Holtz-Eakin, 1994	All state and local government capital	GSP	USA	No effect
Conrad and Seitz, 1994	Transportation infrastructure	Sector output, costs and production	West Germany, 1961-1988	+
Holtz-Eakin and Schwartz, 1995	Highways, water and sewer, gas and electricity	Productivity growth	USA, 1971-1986	No effect
Dalenberg and Partridge, 1995	Highway spending / per income	Employment	Metro areas	-
Moonmaw, Mullen and Martin, 1995	Highways	GSP	USA, 1970-1980-1985	+

Author and Year	Infrastructure Measure	Development Measure	Area, Period and Model	Results
Grihfield and Panggabean, 1995	Highways	Income per-capita growth	282 metro areas	No effect
Singletary et al 1995	Highways accessibility	Manufacturing employment growth	477 areas in South Carolina	+
Morrison and Schwartz, 1996	Highways, water and sewer	Manufacturing costs	USA, 1970-1987	+
Grihfield and Panggabean, 1996	All public capital	Manufacturing output	222 metro areas	+
Boarnet, 1996	Highways	Private output	California USA, 1969-1988	+
Holleyman, 1996	Highways	Manufacturing costs	USA, 1969-1986	+
Garcia-Mila, McGuire and Porter, 1996	Highways	Private sector output	USA, 1970-1983	+
Morrison and Schwartz, 1996	Highways, water and sewer	Manufacturing costs	New England USA, 1970-1987	+
Harmatuck, 1996	All public capital	Gross National Product (GNP)	USA, 1949-1986	+
Bruinsman, Rienstra and Rietveld, 1996	Highways	Employment and firm growth	Netherlands	+
Haughwout, 1996	Highways	Output	2SLS spatial equilibrium model	+
Bollinger and Ihlanfeldt, 1997	Passenger rail stations	Population and employment	Atlanta USA	No effect
Boarnet, 1998	Highways	Output	California USA, 1969-1988	+

Author and Year	Infrastructure Measure	Development Measure	Area, Period and Model	Results
RESI ,1998	Highways	Industry costs and output	Maryland USA, 1982-1986	+
Fernald, 1999	Highways	Industry productivity and output	USA, 1953-1989	+
Lobo and Rantisi, 1999	Local government capital spending	Wage growth	Metro areas	+
Haughwout, 1999	Highways	Residential property values	Metro areas	+
Bougheas, Demetriades and Mamuneas, 2000	Transportation and communication infrastructure	GDP growth	USA, 1978-1992	+
Boopen, 2006	Transportation capital	GDP	38 Sub-Saharan countries and 13 SIDS, 1980-2000, Cobb-Douglas Production Function	+
Zhou, Yang, Xu and Liu, 2007	All public capital	GDP, export and investment	China, 1997-2004	+
Garcia-Mila and Montalvo, 2007	National roads and Highways	Firms located near highways	Spain, 1980-2000	+
Lakshmanan, 2007	All public capital	Private sector productivity and output	USA, Japan, UK, France Germany, India and Mexico, 1951-1987	+