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The Effects of Infrastructure Determinants on Economic Growth: European Union Sample

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Abstract

The infrastructure investments are analyzed by taking the EU 12 and EU 15 division into account as a contribution to previous studies. The study comprised the period between 1980-2010 for EU 15, EU 12 and EU 27 and used generalized momentum method (GMM). Results of the study show that telecommunications investments have positive effects on growth in all groups, energy investments have positive effects in EU 15-EU 27 groups and investments on railway and road have positive effects only in EU 27group.

Keywords: *Infrastructure Investments, Economic Growth, Transportation, Generalized Methods of Moments (GMM).*

JEL Code Classification: H54, O40, R00, C40

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1. Introduction

Within the modern economic and political theory, economic growth and factors of economic growth have been the most popular subjects studied by economists, particularly after the Second World War. In recent years, especially after the 1990's, the choice of economic models and policies to be applied by developing countries to achieve the welfare level of the industrialized countries is heavily discussed in academic environment.

One of the research interests that should be taken into consideration is the effects of infrastructure investment expenditures on Gross Domestic Products (GDP) and economic growth. It cannot be ignored that the experiences of the developed countries are setting examples to the countries following them in the way of achieving welfare. Recent researches deal with problems of economic growth observed in developing countries. In this study we will test if infrastructure expenses are "growth determinants" by taking the expansion process of the European Union and the Member Countries into consideration with drawing a distinction between the first 15 Countries of the Union (EU15) and the latter 12 participating Countries (EU12).

The aim of this study is; to analyze the effects of the determinants of infrastructure investments (transportation, communication and energy) on economic growth in EU countries. Previous studies analyzing the relationship between growth and infrastructure investments can be classified under two headings. The first one is "the studies analyzing the effects of basic infrastructure investments" (Aschauer, 1990; Wylie 1996). The second one is formed by the studies "analyzing of the outputs of the infrastructure investments in terms of qualitative and quantitative indexes" (Robles, 1998; Sahoo *et al*. 2010; Calderon and Serven, 2004).

In this study, we followed the second approach by observing the causality relation between some quantitative indexes of infrastructure investments with economic growth. Besides, the study adopted a classification between the Member Countries as EU 15 and EU 12 considering the dates of becoming members and economic growth levels of the Member Countries. Thus, the relationship of the infrastructure investments of EU 15, EU 12 and EU 27 with growth is projected. In addition to the previous studies, the contribution of this study to the scientific population is that it distinguishes EU 15, EU 12 and EU 27 and presents a scope for comparative analysis by creating alternative models for each group. The rest of this article is organized as follows: Section 2 explains the theoretical framework of the study, section 3 provides literature, and section 4 is about data and methodology, section 5 concerns with the results and section 6 consists of conclusion and remarks.

2. Literature

There are number of empirical studies about the relationship between government expenditure and economic growth. But these studies can be classified under two categories by considering type of variables. According to the this approach, the first group may compose of the studies that handle basic infrastructure investments of the public sector and the infrastructure investments of the private sector as an independent variable. And the second group may consist of the studies that consider the outputs of the infrastructure investments in terms of qualitative and quantitative indexes as an independent variable.

The studies under the first group can be summarized as follows. From an academic view, there has been a rapidly growing literature starting from Aschauer's (1989) study. In his paper, expenditures of the public were classified into two groups as military expenditures and non-military expenditures in a study which dealt with the relationship among public capital stock, growth and efficiency. The examined data covers the period between 1949 and 1985 of US. The least square method was used and it was seen that the increase in the public capital stock was causing an increase in economic growth. The conclusion was public infrastructure investments such as streets, roads, airports, drinkable water and sewerage, play an important role in economic growth and efficiency.

In a similar analyses Verma and Arora, (2010) found out that there exists a long-run relationship between economic growth and growth of public expenditure in case of India.

There are some more studies also analyzed the efficiency for investments. For example Hulten (1996) analyzed the relationship between infrastructure investments and growth put forward that rather than the level of the actualized investments, their efficiency levels were important. In accordance with gathered results, the effects of international support -as regards new infrastructure constructions- on economic growth would be limited. Moreover, as limited resources were not directed to the maintenance and operation of the already available infrastructure investments, this could have caused negative effects on growth.

Some others also analyzed the effect of government on the efficiency of the private sector. For example in the study of Kemmerling and Stephan (2002) causality for 87 metropolitan cities in Germany were analyzed. Panel data analysis was used in the study which covered the years from 1980 to 1988. Results indicate that public capital played a significant role in the productivity of the private sector.

In another study by Canning and Pedroni (1999), the long term effects of infrastructure investments on income per capita were analyzed. This study comprised data between 1950 and1992. Infrastructure data included annual values of physical infrastructure criterion such as the length of sidewalks, electric power production capacity and number of phones. As the study reached to the conclusion that infrastructure investment has long term effects on income per capita in many countries, it supported the endogenous growth model. The result achieved in the study was; what maximized growth in accordance with the established model was emphasized to be the infrastructure level.

Some studies also expand the concept by including the endogenity concept. From this perspective, Agenor (2008) analyzed the relationship between investment and growth. It is assumed that education is a prerequisite for having a productive labor force and infrastructure investments have an effect on school technologies. It is concluded in the study that the infrastructure investments have an impact on educated individuals' production levels. Research of Uhde (2010) also finds parallel outcomes. In the study, the effects of public investment policies on the growth in Germany were analyzed. Accordingly, the relationship between physical infrastructure investments and growth of 16 Federal States was analyzed via panel data. Findings showed that human capital and infrastructure investments had an endogenous effect on growth both in East and West Germany.

Tan *et al*. (2010) contributes the literature by adding analyses of the direction of causality. In the study, two basic theoretical approaches, the Wagner Rule and Keynes Hypothesis are examined in a separate study where the relationship between public expenditures and economic growth is analyzed. The direction of the causality between the variables is analyzed with Granger Test in the study. The existence of a causal connection is not detected from infrastructure investments to GDP.

There are also some studies consider the component of infrastructure expenditures such as transportation. For example, Berechman *et al*. (2006), used the data from 48 States, 18 regions and 389 municipalities of the US, processed to see the effects of highway expenditures actualized within the scope of transportation investments on growth, taking the factors of time and place into account. Findings of the study emphasized that transportation investments had a tremendous spillover effect depending on time and place. In a similar study, Alfredo and Andraz (2011) investigated the relationship between infrastructure investments on regional highway and employment; private investments and growth in Portugal from 1980 to 1988. Data from the five selected regions in the country was analyzed with a VAR model. In accordance with the gathered findings, it was seen that actualized highway investments had positive effects on employment, private investments and long term growth in all selected regions. Furthermore, reducing highway investments, due to budget deficit concerns, had a negative effect on the long term growth.

Kuştepeli *et al*. (2012) also analyzed the relationship among highway investments, growth and international trade was analyzed in Turkey between years 1970-2005. The study used causality and cointegration analysis and in the short run, a very weak relation was discovered between the variables.

Pereira and Andraz (2012) also considered another type of transportation infrastructure such as railway investments. In the study, the effects of actualized railway investments on total and regional economic performance in five regions of Portugal (North, Central, Lisbon, Alentejo and Algarve) were analyzed. A VAR model was used in the study and impulse-response test analysis was carried out. Results on regional basis showed that railway investments in all regions had a positive effect on private sector investments; in terms of employment, they had positive effects only in Lisbon and North regions; as for production, positive effects were seen in all regions except one.

Another type of transportation infrastructure such as airway investments and its effect on growth was analyzed by Yamaguchi in 2011. Cross-sectional analysis was conducted in Japan for 47 cities between 1995 and 2000 by applying Cobb–Douglas production function and growth regression approach. Results of the study show that developments in airway infrastructure investments contributed to growth per capita.

Some other investments form the infrastructure such as telecommunication and its effect on growth was handled by Röller and Waverman in 2011. Findings compiled from 21 OECD countries over a 20-year time span was used to examine the possible effects of telecommunications development. It is estimated that a micro model for telecommunication investment lead to a macro production function. It was seen that, particularly when the necessary amount of telecommunication infrastructure exist, a significant causality connection occurs. According to the Datta and Agarwal (2004) investments in the realm of telecommunication also considered to have a significant effect on economic productivity and growth. By using data from 22 OECD countries, the long-run relationship between telecommunications infrastructure and economic growth was analyzed in this study. Dynamic panel data method was used for estimation. This method provided a correction for the omitted variables bias of a single equation, cross-section regression. In aggregate production functions, differences specific to countries were taken into consideration by the fixed-effects specification. The study indicated that when a series of other factors were controlled, a significant and positive correlation was seen between infrastructure and growth. In another study Lee *et al*. (2012) goes further by analyzing the effects of mobile phones on economic growth in the sub-Saharan Africa. In this region there was a marked asymmetry between land line penetration and mobile telecommunications expansion. The study used the GMM method. It was seen that the expansion of mobile cellular phones was significantly determining the rate of economic growth in sub-Saharan Africa. In addition, these contributions in the field of mobile cellular phones and on the economic growth had been increasingly important. In situations where land line phones were not common, mobile telecommunication had an even greater impact.

Energy infrastructure as a component and its relationship with growth was also analyzed in another study (UNIDO, 2009). Within this article, data from 79 countries from 1970 to 2000 was examined. According to the results, energy infrastructure was an economically significant key factor in explaining why some countries were highly industrialized in comparison to others. The value of energy infrastructure was positive and at utmost importance through all income groups.

Some studies belong to the second group are examined as follows. Robles (1998), analyzed the relationship between infrastructure and growth by establishing two separate sample groups. In his study, Robles concentrated on physical outputs of actualized expenditures rather than the infrastructure expenditures. The researcher used the same technique of Alesina and Perotti (1996) in his study. Thus infrastructure investments of Latin American countries are included in the model as physical outputs like per capita and per km. As a result, it was indicated that physical outputs had positive effect on growth.

Sahoo *et al*. (2010) also contributes the literature by including the private sector into the analysis. Data comprising the period 1975-2007 is used for the economy of People's Republic of China. The infrastructure index had six sub-headings which are as follows: electric power consumption per capita, energy consumption per capita, telephone lines per thousand, railway line per thousand, the number of people using airway and the percentage of sidewalks to the total roads length. Within this study, distributed lag autoregressive approach and generalized moments methods are used and Granger causality tests are carried out. In accordance with the findings, it is seen that developing infrastructure has a tremendous effect on growth. Infrastructure investments have a greater impact than the investments of public and private sector. There is a one-way causality link from infrastructure stocks to growth and a two-way causality link from infrastructure stocks to public-private sector investments

Calderon and Serven (2004) brought another dimension to second group of studies by considering qualitative and quantitative infrastructure investments. They examined the effects of infrastructure investments on economic growth and income distribution by using panel data method. The study involved 100 countries and the period 1960-2000. The infrastructure variables used in the study were grouped as qualitative and quantitative indexes. In accordance with the results achieved from the study, both qualitative and quantitative infrastructure investments affect the growth in a positive manner and reduce the unfair distribution of income.

In another study, relation between transportation infrastructure and regional economic development comprising 31 regions in China in years 1998-2007 was examined by Hong *et al*. (2011). In accordance with the results of the study in which panel data method was used: it was seen that highway and drinkable water infrastructure investments had significant effects on growth. However, there was a positive effect on growth even in the regions where the highway infrastructure investments were low. Whereas water infrastructure investments had positive contribution to growth only when a certain amount of investment was actualized. On the other hand, it was seen that the effect of airways infrastructure investments was not sufficient.

3. Theoretical Framework

Our theoretical approach based on the Barro's (1990) government spending model. Barro's model follows Rebelo (1991) by assuming constant returns to capital;

$$\mathrm{y} = \mathrm{Ak}, \tag{1}$$

Where *y* is output per worker, *k* is capital per worker and A denotes the constant net marginal product of capital and greater than 0. Then model is expanded by combining the government sector. In the model, government expenditure is accepted as productive input for private producers. As a result, this role creates a potentially positive cycle between government expenditure and economic growth.

Given constant returns to scale, the production function is

$$y = \varphi(k, g) = k\varphi\left(\frac{g}{k}\right) \tag{2}$$

Where Φ fits the usual conditions for positive and diminishing marginal products. The variable k is measured as the per capita amount of aggregate capital, where as g is measured by the per capita quantity of government purchases of goods and services. And government expenditure is financed by government tax revenue.

$$g = T = \tau y = \tau . k . \varphi\left(\frac{g}{k}\right) \tag{3}$$

Where T is government revenue, and τ is a flat tax rate.

Then we can obtain

$$T = \left[\left(\frac{g}{y}\right) + \left(\frac{h}{y}\right)\right] . \boldsymbol{y} \tag{4}$$

According to Barro's model, government may affect the growth rate and saving rate. By making a classification of government expenditure such as productive and nonproductive, Barro indicates increase in productive government expenditure will increase the growth rate and saving rate. Briefly, this productive role of government will cause causality between government expenditure and growth. As a result, total production and saving will rise by maintaining this productive cycle. Whereas increase in nonproductive government expenditure will lower the growth rate and saving rate. These effects arise because higher nonproductive government expenditure (h/y) does not have any effect on private-sector productivity, but will cause a higher income tax rate. Receiving smaller part of their returns from investment, individuals will invest less, and the economy will grow at a lower rate.

Barro also suggests that productive government spending would consists of resources devoted to property rights enforcement, and activities that enter directly into production functions.

4. Data and Methodology

In this study the relation between GDP growth and various types of infrastructure expenditures such as airway, railway, highway, telecommunications and energy in EU between1980-2010 is investigated. The Member Countries in the study were divided into two considering the dates of becoming a member to the Union. The relationship between infrastructure investments and growth is analyzed by means of this division as EU 15 and EU 12[1]. Besides, the general view is shown by another model considering EU 27.The EU 15 consists of the first 15 member countries of the Union and in The EU 12 consists of the countries which have become a member during the expansion.

In the study that takes EU 12, EU 15 and EU 27 into account, three separate models are established. In each of these models airway, railway and highway investments exist within the scope of transportation investments. In this manner nine models are established. In addition to these models a forth one dealing with the relationship between transportation investments and growth only for the EU 27is formed.

Our methodological approach brings up some issues faced in empirical evaluations of infrastructure. The first one is about what type of variable to use in the analyses. In contrast with the rich literature that uses the infrastructure in terms of basic infrastructure investments, we consider the physical output of the infrastructure investments such as total length of road. And the second one is intrinsically occurred as there is a two-way causality between dependent and independent variables. To overcome this issue, we perform GMM method.

In the study, GDP per capita growth rate is used as a dependent variable. The independent variables are telephone lines (*ltel*); air transport (*lair*); rail lines (*lrail*); roads, (*lroad*) and energy production (*lenpro*). Logarithm of all independent variables is taken. Instrumental variables (IV) are used to control the endogenity problem arising as infrastructure investments are explanatory variable and the lag value of dependent variable takes place in the study as an explanatory variable. The instruments used in the study are, logarithm of urban population (*lurpop*), population density (*lpopden*) and inflation rate (*linf*).

All the data used in the model is gathered from the World Bank's World Development Indicators.

The model in its broadest sense can be written as follows:

$$growth = \alpha growth_{i,t(-1)} + \beta_1 ltel_{i,t} + \beta_2 lair_{i,t} + \beta_3 lrail_{i,t} + \beta_4 lroad_{i,t} + \beta_5 lenpro_{i,t} + \varepsilon_{i,t} \qquad (5)$$

[1]See Table A1 in the Appendix for the list of countries included in the estimations.

Variables used in the model are defined in Table 1 in accordance with their classified types.

Table 1: Definition of Variables

Type of variable	Variable symbol	Explanation
Dependent	growth	GDP per capita growth calculated as annual percentage change
	ltel	logarithm of telephone lines (per 100 people)
	lair	logarithm of air transport (passengers carried)
Independent	lrail	logarithm of rail lines (total route-km)
	lroad	logarithm of total network (km)
	lenpro	logarithm of energy production (kt of oil equivalent)
	lurpop	logarithm of urban population
Instrumental	lpopden	logarithm of population density
	linf	logarithm of inflation rate

In this study, dynamic panel data model is used since the lag value of dependent variable takes place in the model as an explanatory variable. This dynamic relation in which the lag value of dependent variable is given as explanatory variable can be presented as follows:

$$y_{it} = \delta y_{i,t-1} + x_{it}^{'}\beta + u_{it} \tag{6}$$

in the Equation *i* is horizontal section unit *i*=1,…..N; *t* stands for time *t*=1,…..,T. δ is vector growth, x_{it}' 1xK, β Kx1 dimensional matrix, and u_{it}represents one way error.

$$u_{it} = \mu_i + v_{it} \tag{7}$$

As $\mu_i \sim IID(0, \sigma_\mu^2)andv_{it} \sim IID(0, \sigma_v^2)$, each error terms are independent of each other and among themselves. In the dynamic panel data model emphasized in Equation 1, as the dependent variable exists in the model as explanatory, an autocorrelation problem arises. The autocorrelation problem of the explanatory dependent variable still exists in fixed effect method as well. The GLS (generalized least squares) estimator of random effect model is also biased in a dynamic model (Baltagi, 2005). To overcome the mentioned problems the GMM method is suggested in dynamic panel estimations.

The approach of using the FD (First Difference) is proposed by Anderson and Hsiao (1981) in dynamic models and it easily enabled to overcome the autocorrelation between the predetermined explanatory variables and error term (Baltagi, 2005).Anderson and Hsiao (1981) got rid of μ_i by means of taking the first difference in the model and then as an instrumental variable (instrument-IV), they suggested using $\Delta y_{i,t-2} = (y_{i,t-2} - y_{i,t-3})$ or$y_{i,t-2}$'yi, $\Delta y_{i,t-1} = (y_{i,t-1} -$

$y_{i,t-2})$. As far as these instruments $v_{i,t}$ are not in serial correlation between each other, they will not be in relation with $\Delta v_{it} = (v_{i,t} - v_{i,t-1})$. This instrumental variable prediction method (instrumental variable-IV), maintains its consistency but is not efficient, due to not using all moment conditions and not taking Δv_{it} into consideration (Baltagi, 2005).

Anderson and Hsiao (1982), Holtz-Eakin, Newey, and Rosen (1988) and Arellano and Bond (1991) amongst others, considered the estimation of models with predetermined but no strictly exogenous variables by IV methods using lagged values of the predetermined variables as instruments for the equations in first differences. It is usually maintained that all the explanatory variables are potentially correlated with the individual effects and therefore only estimators based on deviations of the original observations can be consistent. But, if there are available instruments not correlated with the effects, the levels of the variables contain information concerning the parameters of interest which if exploited could improve, sometimes crucially, the efficiency of the resulting estimates (Arellano and Bover, 1995).

Arellano and Bond (1991) then proposed a more efficient estimation procedure (Naveed *et al*. 2011) by using all linear momentum conditions as an alternative to similar previous studies. Their one-step and two-step GMM estimators had more efficient results in comparison with simpler instrumental variable (IV) estimators introduced by Anderson and Hsiao (1981).

GMM utilizes the orthogonality conditions between lagged values of y_{it} and the disturbances u_{it}. GMM procedures not only use the optimal instrument but also rely on the variance-covariance structure obtained from the first-differenced error term (Baglan, 2010).

Consistency of the GMM estimator relies on the validity of instruments. And validity of instruments can be checked by two specification tests: The first of them is Sargan test (test of over-identifying restrictions) which evaluates the validity of the instruments. Null hypothesis indicates that instruments are uncorrelated with the estimated residuals. And the second test is for controlling serial correlation of the residuals. Null hypothesis indicates that the residual of the regression in differences shows no second-order serial correlation (first-order serial correlation of the differenced error term is inherently expected). Failure to reject the null lends support to the model (Calderon and Luis, 2004).

For estimating the models and conducting the specification tests, the STATA statistical programs were used in this study.

5. Results

Table 2 shows the results for the regression estimates where infrastructure expenditures are used as independent variables to check the relation with GDP growth for EU between 1980 and 2010. By taking into consideration the dates of becoming a member to EU 27, models were established under three sub-headings as EU 12, EU 15 and EU 27.

Table 2: GMM-IV Estimation

Dependent variable: GDP per capita growth						
Explanatory variables	**EU 12**					
	Model 1		**Model 2**		**Model 3**	
	B coef.	*t*-stat (sig)	B coef.	*t*-stat (sig)	B coef.	*t*-stat (sig)
growth (-1)	0.463	4.54*	0.675	9.73*	0.568	3.50*
growth (-2)			-0.242	-1.4		
ltel	7.356	2.26**	9.412	2.20**	22.28	1.54
lair	-1.355	-0.7	-	-	-	-
lrail	-	-	47.33	1.22	-	-
lroad	-	-	-	-	-19.6	-0.57
lenpro	-5.232	-1.22	24.15	0.57	-2.97	-0.72
Wald test	X^2 (4) 433.46*		X^2 (5) 294.72*		X^2 (4) 46.02*	
Num.of obs.	227		185		123	
Specification Tests						
Sargan Test	X^2 (59) 8.23		X^2 (54) 5.92		X^2(36) 7.98	
A-B Test for 2nd-order serial correlation (*p*-values)	0.18		0.95		0.24	
Explanatory variables	**EU 15**					
	Model 1		**Model 2**		**Model 3**	
	B coef.	*t*-stat (sig)	B coef.	*t*-stat (sig)	B coef.	*t*-stat (sig)
growth (-1)	0.273	6.16*	0.354	8.67*	0.689	5.76*
growth (-2)	-0.327	-3.53*	-0.128	-1.44	0.25	2.49**
ltel	-3.143	-1.86***	-5	-2.69*	6.124	2.48**
lair	-1.356	-3.29*	-	-	-	-
lrail	-	-	6.940	0.58	-	-
lroad	-	-	-	-	-15.27	-2.42**
lenpro	3.752	2.27**	5.597	2.69*	4.762	4.51*
Wald test	X^2 (5) 145.10*		X^2 (5) 215.98*		X^2 (5) 137.99*	
Num.of obs.	355		351		166	
Specification Tests						
Sargan Test	X^2 (57) 10.56		X^2 (57) 14.06		X^2 (35) 6.8	
A-B Test for 2nd-order serial correlation (*p*-values)	0.84		0.1		0.07	

Table 3 (Cont.): GMM-IV Estimation

Dependent variable: GDP per capita growth								
Explanatory variables	**EU 27**							
	Model 1		**Model 2**		**Model 3**		**Model 4**	
	B coef.	*t*-stat (sig)	B coef.	*t*-stat (sig)	B coef.	*t*-stat (sig)	B coef.	*t*-stat (sig)
growth (-1)	0.601	13.06*	0.637	22.2*	0.899	47.42*	1.004	34.85*
growth (-2)	-0.165	-11.51*	-0.153	-10.57*	-0.184	-27.26*	-	-
ltel	3.063	3*	3.333	4*	9.606	9.14*	-	-
lair	-0.986	-0.23	-	-	-	-	-3.622	-15.79*
lrail	-	-	6.263	1.87***	-	-	8.348	1.95***
lroad	-	-	-	-	-2.879	-1.74***	15.76	4.34*
lenpro	0.075	0.05	2.200	1.3	-1.167	-2.85*	-	-
Wald test	X^2 (5) 8458.01*		X^2 (5) 9090.35*		X^2 (5) 6240.09*		X^2 (4) 1880.80*	
Num.of obs.	577		536		287		250	
Specification Tests								
Sargan Test	X^2 (57) 25.67		X^2(57) 23.68		X^2 (35) 22.03		X^2 (36) 20.60	
A-B Test for 2nd-order serial correlation (*p*-values)	0.33		0.09		0.21		0.79	

Note: *, ** and *** respectively denote significancy at %1, %5 and %10.
A-B Test denotes Arellano-Bond Test.
M1 uses variable of *air* as an indicator of transportation.
M2 uses variable of *rail* as an indicator of transportation.
M3 uses variable of *road* as an indicator of transportation.
M4 uses variables of *air, rail and road* as indicators of transportation.
Instruments; *lurpop, lpopden, linf*.

Further, to study the individual effects of transportation investments under each sub-heading, three sub-models, in which air, rail and road variables separately exist, were established. In addition to this, an extra model, dealing only with the relationship between transportation investments and growth in EU 27 level, was established.

When the first two models are analyzed with EU 12 (the first group), it is seen that one lagged value of dependent variable and *ltel* variable are statistically significant and have a positive effect on growth. In Model 3, except the lag value of the dependent variable, all the variables are found as insignificant, due to low number of observations in road variable data.

In the EU 15 group, all variables of Model 1 are statistically significant. Besides, all the variables, except *lenpro* variable and one lagged value of dependent variable, have a negative effect on growth. In Model 2, two lagged values of dependent variables and *lrail* variable are insignificant. Moreover, *ltel* has a negative effect and the others have a positive effect. In Model 3, all variables are significant and all but Iroad have a positive effect on growth.

In the EU 27 group, one and two lagged values of the dependent variable in accordance with the first model and *ltel* variable are significant. Two lagged values of dependent variable have a negative effect on growth and others have a positive effect. As for the second model, all variables except *lenpro* are statistically significant. As it is in the first model, two lagged values of the dependent variable have negative and the others have positive effects. In the third model all variables are significant. Other than one lagged value of the dependent variable and *ltel*, all variables have negative effect on growth. All the variables in Model 4 are statistically significant. All the transportation variables except *lair* have a positive effect on growth.

When an examination is made in terms of variables, it is seen that one lagged value of the dependent variable is significant and has a positive effect in all models. However, two lagged value is generally significant but has a negative effect.

ltel variable is significant in all models and has a positive effect in all models except Model 1 and 2 in EU 15 group. This finding clearly shows that telephone lines can be seen as a substantial communication tool for trade. This finding is consistent with previous studies (e.g., Röller and Waverman, 2011).

lair variable is significant and has a negative effect only in EU 15 group and in Model 4 of EU 27 group. But this result is not consistent with some previous studies (e.g., Yamaguchi, 2011). The number of the passengers is used to represent the air variable in our study. Inconsistency in the results can possibly be due to differences between the variables used.

lrail variable is significant and has a positive effect only in Model 4 of EU 27 group. This result is consistent with previous studies (e.g., Pereira and Andraz, 2012).

lroad is significant in EU 15; EU 27 and in Model 4. However only in Model 4 it has a positive effect and the gathered result is consistent with some previous studies (e.g., Hong *et al*. 2011; Alfredo & Andraz, 2011; Parpiev & Sodikov, 2008).

lenpro is significant and has a positive effect in three models of EU 15 group. This result is also consistent with previous literature (e.g., United Nations Industrial Development Organization-UNIDO, 2009). This finding can be explained by its indispensable role as a crucial factor of production. Energy investments have a great impact on growth for EU15 as industrialized countries. But in Model 3 of EU 27 it is significant and has a negative effect. In EU 27 group, having negative values for energy investments can be due to the fact that these investments have high costs and contribute to the economic growth only when a certain threshold value is surpassed.

In summary, it is seen that generally in EU 12 group, possible variables are insignificant due to lack of data. Moreover investments on phone lines are significant in all models and have a positive effect. Airway passenger transportation does not have a positive effect on growth. Investments on railway lines are significant only in EU 27 group. Lack of significant data about total road network is one of the limitations of the study. Only in EU 27 level, a positive effect is observed in road investments. Energy production effects the growth positively in EU 15 group.

Wald test statistics show that independent variables used in 10 of the models are statistically significant in explaining the dependent variable. The results of the applied Sargan tests, supports the null hypothesis and indicates that instrumental variables used in the model do not involve endogenity problems. In accordance with the results of Arellano-Bond Test, it is seen that there is not a second degree autocorrelation.

6. Conclusion

The purpose of this study is to investigate the relationship between GDP growth and air, rail, road, telecommunication and energy expenditures in EU during the period of 1980-2010. In the study, member countries were divided into two as EU 15 and EU 12 with respect to the dates of becoming a member to the Union. More analyses are carried out for EU 27 group where all member countries are taken into consideration. In addition to these, a forth model is established only in which the transportation investments are analyzed in EU 27 group.

The results of the study show that the value of growth in the preceding year is positive on the current year growth. Telephone lines within the scope of telecommunications investments, explicitly effect the growth in a positive manner. Therefore, telecommunications investments which are very significant means in coordinating and implementing trade activities must be given a continuous importance.

Airway transportation is regarded to be another important means in trade activities. The effect of the number of passengers using airway transport on growth is analyzed in this study. However, it is seen that airway transport does not contribute to growth in this sense. The amount of freight carried by airway can be handled in further studies. The study implies that railway investments, another means of transportation, have a positive effect on growth. In accordance with this railway investments which lead to low transportation costs of goods, will maintain its contributions to forthcoming economy of the Union. In road, which is transportation heading, the number of observations is very low, due to lack of sufficient data. In addition to transportation investments, it is seen that energy production supports growth in EU 15. Results show that policies, developing infrastructure investments in the fields of energy, railway and telecommunications, have an undeniable role in increasing per capita income.

Another result that can be derived from the study is that in 12 member countries, become members in the recent two expansion processes, infrastructure investments carried out in the realm of telecommunications support the growth but are not sufficient in the countries of this group. According to the catch-up effect, impact of additional infrastructure investment on subsequent growth will be prominent. In other words, investing on more physical capital in these countries will substantially contribute to their production. Within this context, both in national and in regional policies pursued by the Union, it is beneficial to overcome these deficiencies before they lead to an imbalance between the member countries.

In subsequent studies, other physical output of infrastructure variable may be used as a measurement such as number of the goods carried by air, rail, road, and sea transport; number of passengers carried by road, rail, and sea transport.

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Table A1: List of selected countries

EU 15	EU 12
Belgium[a]	Cyprus[f]
France[a]	Czech Republic[f]
Germany[a]	Estonia[f]
Italy[a]	Hungary[f]
Luxembourg[a]	Latvia[f]
Netherlands[a]	Lithuania[f]
Denmark[b]	Malta[f]
Ireland[b]	Poland[f]
United Kingdom[b]	Slovak Republic[f]
Greece[c]	Slovenia[f]
Spain[d]	Bulgaria[g]
Portugal[d]	Romania[g]
Austria[e]	
Finland[e]	
Sweden[e]	

Note: [a]Founded the EU on 01/01/1957.
[b] Joined the EU on 01/01/1973.
[c] Joined the EU on 01/01/1981.
[d] Joined the EU on 01/01/1986.
[e] Joined the EU on 01/01/1995.
[f] Joined the EU on 01/05/2004.
[g] Joined the EU on 01/01/2007.