International Review of Business and Economics

Volume 2 | Issue 2 Article 2

10-1-2018

Impact of Infrastructure on Economic Growth: A Panel Data Approach Using PMG Estimator

Esra Kabaklarli
Selçuk University, etalasli@selcuk.edu.tr

Fatih Mangir
Selçuk University, fmangir@selcuk.edu.tr

Bansi Sawhney
University of Baltimore, bsawhney@ubalt.edu

IMPACT OF INFRASTRUCTURE ON ECONOMIC GROWTH: A PANEL DATA APPROACH USING PMG ESTIMATOR

Esra KABAKLARLI (Selçuk University, Turkey)[1]
Fatih Mangır (Selçuk University, Turkey)[2]
Bansi Sawhney (University of Baltimore)[3]

Abstract

Growth theory asserts that infrastructure investments promote economic growth by improving the quality of life and increasing private sector productivity . Transport services, water utility services and telecommunication services provide better facilities to attract FDI (foreign direct investment) and increase productivity across sectors. The aim of this article is to analyze whether transport infrastructure investments have a strong effect on the economic growth. It also attempts to analyze the differential impact of each type of infrastructural spending on economic growth. Our data set covers annual data from 1993 to 2015 period for 15 OECD countries (Austria, Turkey, Czech Republic, Spain, Finland, Japan, Germany, Ireland, Italy, France, Korea, Mexico, Netherlands, Poland, U.K) and China.

In this study, we employ a Pool Mean Group (PMG) estimator to find long run and short run relations between the variables. Output elasticity of air transport is found to be positive and significant at five percent level and there exists a long run relationship between GDP per capita and other explanatory variables such as transport infrastructure indicators, gross capital formation and labor force. The crowding- out hypothesis is also supported by coefficients on county specific results. Our data set includes infrastructure variables such as Railways, (million passenger-km), Air transport, (freight, million ton-km), Individuals using the Internet (% of population).

[1] Selçuk University, Faculty of Economics and Administrative, Department of Economics, Konya,Turkey
e-mail: etalasli@selcuk.edu.tr
[2] Selçuk University, Faculty of Economics and Administrative, Department of Economics, Konya,Turkey
e-mail: fmangir@selcuk.edu.tr
3 Merrick School of Business, University of Baltimore, MD. USA. E-mail: bsawhney@ubalt.edu

IMPACT OF INFRASTRUCTURE ON ECONOMIC GROWTH:

A PANEL DATA APPROACH USING PMG ESTIMATOR

Introduction

Economists in both developed and developing countries have recognized that infrastructure spending plays a crucial role in the process of economic growth of a country. Output elasticity of such spending has been found to be high and significant in the U.S. and other developed countries (Aschauer, 1989). According to the economic theory, the marginal productivity of public investment should be even higher in the case of less developed countries where the stock of public capital is much lower compared to developed countries. In fact, the Global Monitory Report of the World Bank (2005) calls for a big push in such spending for many countries.

Infrastructure affects growth through various transmission mechanisms. Public infrastructure investments improve private sector by increasing enterprise productivity(Aschauer 1989; Barro, 1990). Roads, bridges, highway and various transportation facilities , water , sanitation and electric system, waste disposal and public utilities promote economic activities by decreasing cost of the goods and services..(Orszag, 2009) Water utility services, cheap and clean energy , developed roads , bridges , highways and telecommunication facilities serve as stimulus to increase efficiency in all sectors, which could lead to increased employment and income levels and a reduction in poverty (Asian Development Bank, 2012).Infrastructure can be classified as:

- transport infrastructure: roads, airports, seaports, rail
- energy and utilities infrastructure: electricity, water, gas
- telecommunication infrastructure: fixed line penetration, mobile cellular penetration

as well as social infrastructure, including healthcare, education and cultural facilities. (Singhal, 2011)

A large majority of studies have used a production function approach to determine the role of public expenditure in economic growth measuring the direct contribution of such spending. However, public spending may have substantial indirect effects that facilitate private capital formation by reducing transportation and communication costs of production.

It has also been found that infrastructure spendings lead to improvements in health and education outcomes, which further contribute to economic growth (Agenor and Moreno-Dodson, 2006). It has also been found that improvements in communication have helped farmers receive the latest information on prices of imports and their products. This information helps them to make the optimal decisions. Access to increased inputs such as electric power and water supply have reduced the cost in both agricultural and industrial sectors in many countries and contributed to improvements in economic and social life of their citizens (Sahoo and Dash, 2012).

From public policy standpoint, the decision makers need to maximize total welfare gains from spending in infrastructure. Such decisions require optimal allocation of total spending where the marginal social benefits and social costs are equated for each type of spending. In this paper, we try to analyze the role of infrastructure spending in different sectors of the economies in 16 countries.

1.Literature Review

Investigating the relationship between infrastructure spending and economic growth has received a great deal of attention from economist in both developed and developing countries. There is extensive literature analyzing the effects of public investment on economic development and growth. A large number of studies have concluded that public investment affects growth positively. The theoretical argument in these papers is based on the simple Keynesian macroeconomic model in which spending on infrastructure leads to higher aggregate demand and greater incomes and through multiplier effects it further increases GDP.

Literature review shows two different results for infrastructure effects on economic growth. The majority of the literature advocates positive effects of infrastructure on economic growth. Caldero´n, and L. Serve´n. analyzed 101 countries applying GMM panel data approach for the period 1960–1997. They found that positive and significant estimates of the real GDP contributions of all three infrastructure (telecom, transportation and energy) output considered. Salahuddin and Alamthe (2015) used Pooled Mean Group Regression to examine short- and long-run effects of Information and Communication Technology (ICT) use, electricity consumption and economic growth. They also run causalities tests for OECD countries using data for 1985–2012. According to their results ICT use causes electricity consumption and economic growth. Jalilian and Weiss' (2004, p. 3). Iradian (2005) used A panel dataset for 82 countries for the period 1965–2003 . They also argue that social infrastructure spending on health, education, and social sector are necessary to combat poverty and improve human health. The linkage between social infrastructure spending and income distribution is powerful, and public spending on social sectors like education and health improves income distribution in the long run. Sahoo and Dash use Panel Cointegration and Granger causality techniques for a panel of four South Asian countries for the period 1980–2005, find positive and significant long-run relationship between real GDP and infrastructure along with other explanatory variables. The results reveal that real domestic capital formation, labor force, real export , expenditure on health and education lead to a positive contribution to real GDP.

The seminal paper by Aschauera(1989), concludes that infrastructure spending has a highly significant effect on national output and that output elasticity of infrastructure spending is between 0.38 and 0.56 for the U. S. He uses time series data and estimates the impact of public investment on total factor productivity by employing a production function approach. His finding of such a high number for output elasticity, which in some exceeds the contribution of total capital, has attracted the attention of many scholars and subsequent studies using cross-section as well as time series data find a much lower number for such elasticities Munnell (1990),for example, uses data for seven OECD countries over the 1963-1988 and finds that elasticity coefficient of output and infrastructure is 0.49. Heyden's (2004) study includes a sample of 46 countries and finds that output elasticity is 0.31 These studies support Ashauer's findings. However, several other authors do not agree with these findings and using alternative models and data sets discover lower elasticities in their research. For example, Fin (1993) uses U. S. data over the 1950-1988 period and finds a positive effect of infrastructure but the elasticity number is only 0.16. Bajo and Sosvilla (2003), use a production function approach over 1964-1988 period and comes up with the elasticity number that is only 0.13. Similar findings are reported in Calderon and Serven 2003. They use data from 101 countries over 1960-1997 and conclude that output elasticity is only 0.16.

As noted above, the findings of a majority of studies supports the growth-enhancing impact of infrastructure as they find a positive output elasticity of infrastructure spending. There are other researchers who are not in agreement with their findings. They claim that public spending may have a negative impact on economic growth. According to them, public spending decisions are politically motivated and public spending projects are not productive since they are influenced by political considerations. The Marginal productivity of such spending is close to zero or even negative. Further, they may also replace or reduce private investment spending. This case is referred to as crowding -out by Agessor and Morren-Dodson. As is commonly observed in less developed countries spending on infrastructure maintenance is often mis-allocated which may adversely affect productivity and growth and leads to higher levels of corruption. Moreover, it may be argued that the financing of public spending negatively impacts productivity when distortionary taxes are imposed or public debt is increased due to these types of spendings. Infact there are several studies that have found a negative impact of infrastructure spending. For instance, Devarajan et al. (1996), in their study, using a sample of 43 countries concludes that there is a negative correlation between public investment and growth. Similarly, Sanchez-Pobles (1998) find a negative correlation between output and public investment for a sample of 96 countries.

Barro (1990) shows investing in public infrastructure has both negative as well as positive effects. Public expenditures for productive infrastructure investment increases the GDP per capita and therefore leads sustained per capita growth. However increase in unproductive infrastructure investment which is financing by taxing income reduces per capita GDP growth. Agenor and Moreno-Dodson (2006) concluded that infrastructure has a negative role in economic growth . Public spending on infrastructure make crowding out,effect that in the short run, an increase in public spending on infrastructure would decrease finance opportunities of private sector. This negative crowding out effect of infrastructure may turn into a long-term negative effect if the decrease in private capital formation persists over time (Dissou and Didic 2013).Ghali (1998) argues that public investment in economic infrastructure enables operation of private investment in undeveloped countries. He applied vector error-correction model for Tunisia over the period 1963-1993. According to this paper , public investment has a negative impact on GDP growth and private investment in the long run, and also that public investment has no impact on GDP growth in the short run.

It is to be noted that several studies have found a statistically insignificant relationship between public investment and output. For example, Evans and Karras (1994) find insignificant relationship between public capital and output in the case of OECD countries over 1963-1988. In the case of U.S., Hamatuck (1996) find elasticity to be only 0.03 between public capital and output. Similar results are obtained by Hutton and Schwab (1991). Kavanaught (1997) uses data for Ireland over 1958-1990 and finds insignificant relationship between output and public investment. (For a more comprehensive survey see Pereira and Adraz, 2013).

Infrastructure decreases transport and production costs and facilitates business activity and foreign direct investment. Égert et al. (2009) applied time series and panel data approach using the data on 24 OECD countries for the years between 1960-2005. They find that infrastructure investment in non-transport sectors such telecommunications and the electricity sectors have a strong positive effect on GDP growth rate in the long term. However , transport infrastructure (railways and motorways) coefficients are found to be statistically insignificant. Pereira and Roca-Sagalés (2003) estimate VAR models for Spain using transportation (railroads , airports, roads, port) and communication indicators as representative of public infrastructure between the years 1970-1995 . They found the marginal productivity of public capital is 2.892, it means that one-euro increase in public capital leads to a long-term accumulated increase in private output of 2.892 euros.

As noted above, a great deal of effort has been devoted to examine the relationship between output growth and infrastructure. The results have varied and no consensus has emerged. Some studies have found significant, while others have found an insignificant or even negative impact of infrastructure spending on growth. Differences in results may be due to different model specification and statistical methods used. They may also vary over different time- periods and across countries and thus call for more studies in this field. This paper focuses on various components of infrastructure. It attempts to analyze the differential impact of different types of infrastructure spending on economic growth in 16 countries. It is not just the total spending that matters but what matters is where and how that money is spent. The findings of this study will have important policy implications in suggesting which sectors of the economy get maximum benefits from public spending.

2. Data and Methodology

In the empirical part of our study, we analyze the infrastructure and economic growth relationship i.e. effects of infrastructure investment on economic growth. Our dependent variable is natural logarithm of GDP per capita (constant 2010 US$).We include major infrastructure indicators as follow ; natural logarithm Air transport, freight (million ton-km), natural logarithm Railways, passengers carried (million passenger-km), Individuals using the Internet (% of population). We also use ,Gross capital formation (% of GDP), natural logarithm labor force as additional regressors. The gross fixed capital formation(% of GDP), is employed as the measure of investment . The labor is explained as total labor force . All of our data are obtained from the World Bank databank. Table 2 denotes the definition of the variables.

Table 1. Definition of Variables

Variables	**Indicator Name**
Index	Principle Composite index of transport infrastructure
lnAIR	Air transport, freight (million ton-km)
lnRAIL	Railways, passengers carried (million passenger-km)
GDP GRWT	Natural Logarithm of GDP per capita (constant 2010 US$)
GFC	Gross capital formation (% of GDP)
INTERNET	Individuals using the Internet (% of population)
LNLABOUR	Labor force, total

Our data set covers annual data from the 1993-2015 period for 16 OECD countries (Austria, China, Czech Republic, Finland, France, Germany, Ireland, Italy, Japan, Korea, Mexico, Netherlands, Poland, Spain, Turkey, and the U.K. We got all the data from the World Bank databank. Considering the heterogeneous nature of our data set we define a dummy variable to control for cross-country differences. The dummy takes value of 1 if it is an developed country and 0 if it is an developing country. Since factors such as infrastructure indicators , railway, air transport , internet and investment are affected by a country's development level, slope dummies (which are obtained by multiplying the dummy variables with the variables of interest) allows us to distinguish between development level differences . For example, multiplying air transport per capita with the dummy variable shows us whether growth rate gets affected by infrastructure differently in advanced and emerging economies.

2.1. Cross-section dependency and homogeneity Analysis

Cross section dependence can emerge due to many factors, such as excluded observed common factors, spatial spill over effects, unobserved common factors, or general residual interdependence that could remain even when all the observed and unobserved common effects are considered (Breitung and Pesaran,2008 :295). A shock that affects one country may spill over on other countries. Because of this one essential step to be taken in a panel data analysis is examining for cross-sectional dependency throughout the countries. (Nazlıoğlu,at all, 2011:6618).

$$y_{it} = \alpha + \chi_{it}{}' \beta'_i + u_{it} \quad (1)$$

Where i indexes the cross-section dimension and t time, ,x_{it} is a k x1 vector of rigidly exogenous regressors with slope parameters .$\beta_{i..}$ Breusch and Pagan (1980) advanced a LM statistic for testing the null hypothesis of cross-sectional independence.The test is based on the following LM statistic:

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{p}\, 2_{ij} \quad (2)$$

Where ρ^ij is the sample estimate of the pair-wise correlation of the residuals from individual ordinary least squares (OLS) estimation of the Eq. (1) for each i. However,LM test is likely to cause substantial size distortions with large N and small T (Peseran at all, 2008). Pesaran (2004) developed a more general cross-sectional dependency tests (CD) to manage the large N bias of the LM test.

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{p}_{ij} \right) \quad (3)$$

The results from cross-section dependency tests reported in table 3 point out the null hypothesis of cross-sectional independence is rejected at different level of significance. The existence of cross-sectional dependency requires that we must carry out a unit root analysis which consider for dependency in modelling affects of infrastructure on economic growth (Nazlıoğlu at all, 2014)

Table.2 Cross-section dependency tests

constant	Rail Statistic	p-value	Air Statistic	p-value	internet Statistic	p-value
CD_{lm} (BP,1980)	195.875	0.000	301.153	0.000	243.803	0.000
CD_{lm} (Pesaran, 2004)	4.898	0.000	11.693	0.000	7.991	0.000
CD (Pesaran, 2004)	0.759	0.224	-2.568	0.005	-2.712	0.003
LM_{adj} (PUY, 2008)	2.869	0.002	7.182	0.000	5.019	0.000
constant	GDP Statistic	p-value	GFC Statistic	p-value	Labour Statistic	p-value
CD_{lm} (BP,1980)	192.586	0.000	171.755	0.001	146.631	0.050
CD_{lm} (Pesaran, 2004)	4.685	0.000	3.341	0.000	1.719	0.043
CD (Pesaran, 2004)	-1.801	0.036	-0.350	0.363	-2.589	0.005
LM_{adj} (PUY, 2008)	9.615	0.000	0.410	0.341	-1.404	0.920

2.2. Unit Root Analysis

Before examining the impact of infrastructure on economic growth, the stationarities of the series, should be checked. Dealing with the problem of cross-section dependence, the cross section augmented Dickey–Fuller (CADF) test is used to check whether the series have a unit root or not. The cross section augmented Dickey–Fuller (CADF) test is based on the following regression (Peseran, 2007)

$$\Delta y_{it} = a_i + \emptyset y_{i,t-1} + b_i \bar{y}_{t-1} + c_i \bar{y}_t + e_{it} \qquad (4)$$

Having found the presence of cross-sectional dependence in the panel, an appropriate unit root test is the cross-sectionally augmented ADF (CADF) test for unit roots in heterogeneous panels was performed by Pesaran (2007). The critical values and CADF statistics are shown in table 4.

Table 3. Panel Unit Root Test, Peseran CADF and Fourier panel stationarity test

	CADF-stat			Fourier panel stationarity test	
	Lags	Constant	Constant and Trend	Constant	Constant and Trend
GDP GRWT	3	-1.28	-1.51	1.2375 (0.1080)	16.7891 (0.0000)
lnAIR	3	-1.96	-2.24	2.3543 (0.0093)	13.1612 (0.0000)
lnRAIL	3	-1.20	-2.14	24.4847 (0.0000)	12.6535 (0.0000)
INTERNET	3	-2.33**	-2.29	1.4127 (0.0789)	11.4864 (0.0000)
LNLABOUR	3	-1.57	-1.86	0.3819 (0.6487)	5.5375 (0.0000)
GFC	3	-1.74	-2.13	16.3183 (0.0000)	16.1529 (0.0000)
		10%		5%	1%
Critical values at constant		-2.07		-2.15	-2.32
Critical values at constant and trend		-2.58		2.67	2.83

*Max lag is considered 3 and selected as , Schwarz information criteria

The individual statistic is based on the Fourier panel stationarity test, which examine the null of stationary, showing that labor and GDP per capita series are stationary, I(0) on the contrary, internet, railway, airline and gross capital formation series are non- stationary at the % significance level. According to CADF-stat (constant and trend) all the series are stationary at the first difference, all of them are I (1).

Examining whether slope coefficients are homogeneous or heterogeneous is essential in a panel cointegration analysis. Delta test $\tilde{\Delta}$t and Adjusted Delta test $\tilde{\Delta}$t approach are used to test the homogeneity of a subset of slope coefficients (Pesaran and Yamagata, 2008).

$$\tilde{\Delta} = \sqrt{N}\left(\frac{N^{-1}\tilde{S} - k}{\sqrt{2k}}\right) \qquad (4)$$

$$\Delta_{adj} = \sqrt{N}\left(\frac{N^{-1}\tilde{S} - E(\tilde{z}_{iT})}{\sqrt{Var(\tilde{z}_{iT})}}\right) \qquad (5)$$

Where, $\Delta^{\sim}$ is the cross section dispersion of individual slopes weighted by their relative precision. The null hypothesis of interest is

$H_0 : \beta_i = \beta$ for all i,

against the alternatives

$H_1 : \beta_i = \beta_j$

When we reject null hypothesis, then we can conclude that series are homogeneous. Results of our cross section dependency test and slope homogeneity test are shown in table 5

Table 4. Cross section dependency test and slope homogeneity test

Cross Section Dependency test			**Homogeneity test**		
Test	Statistics	P value		Statistics	P value
LM (Breusch & Pagan 1980)	184.879	0.000	Delta_tilde	9.744	0.000
CD lm (Pesaran 2004)	4.188	0.000	Delta_tilde_adj	11.578	0.000
			Swamy Shat	718.353	0.000
CD (Pesaran 2004)	3.908	0.000			
LMadj	4.736	0.000			

2.3. Cointegration Analysis

We employ LM bootstrap test for the null hypothesis of cointegration and Westerlund cointegration test for the null hypothesis of no cointegration in panel data. Results of the panel cointegration tests are presented in Table 6. All the test statistics reject the null of no cointegration hypothesis at 10 and 5 percent level of significance for

Westerlund cointegration test. We accept the null of cointegration hypothesis according to Bootstrap p-value for LM bootstrap cointegration test**.**

Table. 5. Cointegration Test

Tests	Statistic	Asymptotic p-value	Bootstrap p-value
LM bootstrap			
(Ho: cointegration)			
LM_N^+	24.911	0.000	0.509

Tests	Statistic	Critical values	
Westerlund		1.28	10%
Durbin_h Tests,			
(Ho:No cointegration)		1.645	5%
dh_g	-1.895**		
dh_p	-1.346*	2.333	1%

The results exhibit the cointegration between GDP per capita and infrastructure indicators. The cointegration parameters are estimated by the pooled mean-group (PMG) estimator of Pesaran, Shin, and Smith, which provides short and long term parameters with error correction components are shown in table 7 (Paseran at all 2007). PMG estimator allows coefficients and error variances to differ freely across countries in the short run . However PMG assumes long run homogeneity among the panel group. PMG estimator gives advantage to calculate error correction term which measures the speed of adjustment towards the long-run equilibrium (Fedderke and. Kaya ,2013)

Table 6. Long Run and Short Run Parameters of Panel PMG Results

	Equation 1		Equation 2 with Dummy Variables	
	Coef.	P value	Coef.	P value
Long Run				
Air	-0.065	0.252	-0.085	0.26
Rail	-0.098	0.423	0.020	0.86
Internet	0.002	0.190	0.002	0.26
labor	1,470	0.147	0.567	0.71
GFC	0.007	0.001	0.007	0.00
dumair			0.019	0.76
dumrail			0.002	0.98
duminternet			0.002	0.24
Short Run				
Error Correction	-0.383	0.000	-0.365	0.00
D(Air)	0.024	0.049	0.033	0.02
D(Rail)	-0.045	0.302	-0.049	0.27
D(Internet)	-0.001	0.021	0.0004	0.18
D(labor)	0.388	0.016	-0.352	0.03
D(GFC)	0.002	0.000	0.002	0.00
dumair			-0.009	0.24
dumrail			0.006	0.12
duminternet			0.0002	0.37

The error-correction term is negative and significant. All the long-run coefficients of panel estimation are insignificant except gross capital formation (% of GDP) which we used as a proxy of investment, will lead to 0.07 % increase in GDP per capita growth in the long term. All the short run coefficients except railway, exhibit significant relationship with GDP per capita. As mentioned in section 1, we define a slope dummy variable to classify countries as a developing or a developed country according to the specification used by the IMF. Then we multiply this dummy with infrastructure indicators(air transport , railway , internet) add it as an extra regressor to decompose the developing - developed country effect. Appropriately, the slope dummy term for infrastructure has insignificant coefficient. This shows that emerging countries infrastructure policies effects on the growth do not differ from developed countries. Because of this insignificant dummy effect we consider only equation 1 .

According to growth theory , we expect infrastructure expenditures to affect economic growth positively. In parallel with our expectations, air transport coefficient is significant with a positive sign in the short run panel PMG estimation. The short -run coefficient of air transport (proxy for infrastructure) is 0.027 and is significant , indicating that a 1% increase in the air transport is probably to increase GDP per capita by about 0.024%. Contrary to our expectations, internet coefficient is significant with a negative sign in the short run. Railway coefficient is insignificant with a negative sign. 10 percentage point increase in investment expenditures to GDP ratio will lead to a 0.02 percent increase in growth. One percent increase in labor will lead to a 0.38 % increase in economic growth. The short term parameters of panel PMG estimation suggest that countries which are included our model must focus on labor , air transport and investment to stimulate economic growth .

Table 7. Long Run Country PMG Estimation Results

Countries	Labor	GCF	Air	Rail	internet
Austria	0.549 (0.287)	0.007*** (0.010)	0.047 (0.127)	-0.203** (0.025)	0.001* (0.011)
Czech Republic	0.627 (0.859)	0.014 (0.126)	0.175 (0.313)	-0.958 (0.223)	0.002*** (0.000)
France	11.373 (0.746)	-0.005 (0.923)	-0.691 (0.765)	0.341 (0.813)	-0.009 (0.758)
Finland	0.244 (0.649)	0.011*** (0.000)	-0.116** (0.021)	0.634*** (0.012)	0.001*** (0.001)
Germany	-0.528 (0.354)	0.010*** (0.001)	-0.174*** (0.000)	0.437*** (0.000)	0.001*** (0.000)
Ireland	3.859** (0.059)	0.001 (0.893)	-0.360 (0.470)	-0.653 (0.425)	-0.004 (0.210)
Italy	-0.944 (0.304)	0.010*** (0.009)	0.100* (0.064)	0.052 (0.836)	0.001 (0.164)
Japan	3.364** (0.025)	0.001 (0.750)	-1.187** (0.037)	-0.478 (0.142)	0.001*** (0.000)
Korea, Rep.	2.878*** (0.000)	-0.0008 (0.516)	0.011 (0.730)	0.112** (0.022)	0.0006*** (0.000)
Mexico	0.737 (0.815)	0.006 (0.165)	0.0008 (0.987)	-0.008 (0.318)	0.001 (0.238)
Netherlands	1.780** (0.054)	0.004 (0.164)	0.115 (0.412)	0.080 (0.518)	-0.0003 (0.733)
Poland	-3.092 (0.444)	0.011* (0.084)	-0.014 (0.930)	-0.098 (0.802)	0.004* (0.076)
Spain	-0.076 (0.604)	0.004*** (0.000)	0.128*** (0.000)	0.509*** (0.000)	-0.0001 (0.637)
Turkey	-4.560 (0.690)	0.024 (0.588)	0.213 (0.829)	-0.783 (0.653)	0.012 (0.499)
United Kingdom	-1.023 (0.171)	0.020*** (0.000)	-0.146* (0.068)	0.144 (0.328)	0.001*** (0.000)
China	9.004*** (0.000)	-0.006 (0.373)	-0.146 (0.356)	0.694 (0.230)	0.012*** (0.010)

Note: Figures in parentheses refer to p value. ***, ** and * denote statistically significant at 1%, 5% and 10%, respectively.

The above table lists results of all variables used in the study. For countries such as Mexico, Turkey ,Netherlands, France and Ireland, none of the variables are significant .This finding is important since it supports the crowding-out hypothesis.

Only one of the infrastructural variables is important for Italy, Czech Republic, Japan, Poland and China. Countries such as Spain, Austria, Korea and U.K. show better results but only in two countries, Finland and Germany, we find that all three infrastructure variables (internet, railway and airway) are positive and significant .

Table 8. Short Run Country PMG Estimation Results

Countries	ΔLabor	ΔGCF	ΔAir	ΔRail	Δinternet
Austria	-0.636 (0.127)	0.0003 (0.869)	-0.007 (0.794)	0.085 (0.146)	-0.001* (0.075)
Czech Republic	0.581 (0.556)	0.003** (0.013)	-0.0008 (0.965)	0.187* (0.095)	-9.83e-06 (0.982)
France	-0.527* (0.065)	0.004*** (0.000)	-0.012 (0.485)	0.039 (0.394)	0.0002 (0.180)
Finland	0.637 (0.405)	0.00009 (0.978)	0.080** (0.030)	-0.523** (0.030)	-0.0005 (0.372)
Germany	0.863* (0.082)	-0.0006 (0.708)	0.015 (0.645)	-0.322*** (0.003)	-0.0002 (0.381)
Ireland	1.503 (0.370)	0.002 (0.487)	0.140 (0.329)	-0..041 (0.868)	-0.004** (0.044)
Italy	-0.034 (0.917)	0.001 (0.457)	0.005 (0.630)	0.019 (0.767)	0.0002 (0.550)
Japan	1.208* (0.076)	0.006** (0.012)	0.096 (0.160)	0.097 (0.353)	0.0003 (0.929)
Korea, Rep.	0.522 (0.256)	0.002*** (0.000)	0.027** (0.024)	-0.013 (0.563)	-0.0005*** (0.006)
Mexico	0.281 (0.585)	0.0005 (0.903)	-0.006 (0.864)	-0.021* (0.073)	-0.0008 (0.515)
Netherlands	1.003 (0.128)	0.007** (0.042)	0.081 (0.166)	0.007 (0.944)	0.0003 (0.238)
Poland	-0.623 (0.866)	0.001** (0.030)	-0.005 (0.605)	-0.014 (0.722)	-0.0004 (0.414)
Spain	-0.049 (0.749)	0.0021 (0.000)	-0.030 (0.218)	-0.177 (0.005)	0.0008 (0.604)
Turkey	-0.516 (0.217)	0.003 (0.004)	-0.032 (0.526)	0.070 (0.322)	-0.001 (0.434)
United Kingdom	0.510 (0.312)	0.001 (0.474)	0.004 (0.815)	0.020 (0.710)	-0.0005*** (0.013)
China	0.929 (0.562)	-0.0008 (0.481)	-0.034 (0.176)	-0.135* (0.011)	-0.001 (0.335)

Note: Figures in parentheses refer to p value. ***, ** and * denote statistically significant at 1%, 5% and 10%, respectively. Δ refers to first difference all of the variables.

.

Table 8 above reports the short-run results which are not significantly different than the long run results.

Conclusion and Summary

In this study, we examined the effect of infrastructure on economic growth in 16 countries after controlling for other principal variables such as gross capital formation (proxy for investment), labor force. We used Pool Mean Group panel analysis for the period 1995 to 2015. Railways, passengers carried (million passenger-km), Air transport, freight (million ton-km), Individuals using the Internet (% of population), variables are used as proxy for the infrastructure.

The results of the panel analysis for the period 1995–2015 display that GDP per capita elasticity of labor is positive and significant in the short run. The impact of capital formation (investment) on GDP is also positive and significant in both the long and short run. Additionally, our study has important implications that the GDP per capita elasticity of the air transport is positive and statistically significant at 5% level. Contrary to our expectations, internet coefficient is significant with a negative sign in the short run. Railway coefficient is insignificant with a negative sign.

Our results are in line with the findings of Agenor and Moreno-Dodson (2006) and Dissou and Didic (2013) who found negative and insignificant coefficients of public spending. Because of the crowding -out effect, heavy public infrastructure spending adversely affects private investment in the economy. It may also lead to more corruption and negative productivity growth.. The slope dummy term for infrastructure has insignificant coefficient. This shows that for emerging countries, infrastructure policies' effects on growth do not differ from developed countries. If developing countries focus on more infrastructure investment such as roads, bridges, highways, and neglect very productive manufacturing sectors then it will lead to negative effects on per capita GDP.

We also report results for specific counties using PMG estimation technique. Only developed countries such as Finland and Germany show positive and significant relation between public investment and per capita growth. All of the PMG estimation parameters are insignificant for countries such as Turkey and Mexico in the long run . Specific country short run PMG estimation results show that a majority of countries have insignificant infrastructure parameters. Future studies should further explore the impact of infrastructure spending at individual country level and see if the level of economic development matters.

BIBLIOGRAPHY AND REFERENCES

Agenor P-R, Moreno-Dodson B (2006) Public infrastructure and growth: New channels and policy implications. World Bank Policy Research Working Paper 4064 (November), Washington, DC

Asian, Development Bank. Infrastructure for Supporting Inclusive Growth and Poverty Reduction in Asia, edited by Development Bank Asian, Asian Development Bank, 2012

Barro RJ (1990) Government spending in a simple model of endogenous growth. J Polit Econ 98 (5):103–125

Barro RJ., (2003) "Determinants of Economic Growth in a Panel of Countries," Annals of Economics and Finance, Society for AEF, vol. 4(2), pages 231-274, November.

Caldero´ n, C., and L. Serve´n. 2003. The output cost of Latin America's infrastructure gap. In The limits of stabilization: Infrastructure, public deficits, and growth in Latin America, ed. W. Easterly, and L. Serve´n, 95–119. Washington, DC: Stanford University Press. CESifo Working Paper 1229; IZA Discussion Paper 1240.[970].

Cobb, C.W.; Douglas, P.H. 1928. A theory of production. The American Economic Review Supplement, Papers and Proceedings of the Fortieth Annual Meeting of the American Economic Association (Mar., 1928) 18 (1): 139-165.

Devarajan,s.,Swaroop,v. and Zou,H.,(1996).The Composition of Public expenditure and Economic Growth,Journal of Monetary Economics 37:313-344

Dissou and Didic (2013*) Infrastructure and Growth*, edit Cockburn, J et all in Infrastructure and Economic Growth in Asia, Springer.

Égert, B., T. Koźluk and D. Sutherland (2009), "Infrastructure and Growth: Empirical Evidence", OECD Economics Department Working Papers, No. 685, OECD Publishing, Paris.

Engel, Eduardo, Ronald Fischer and Alexander Galetovic, 2008. "Public-Private Partnerships: When and How". http://www.econ.uchile.cl/uploads/publicacion/c9b9ea69d84d4c93714c2d3b- 2d5982a5ca0a67d7.pdf

Fedderke, J.W. and. Kaya, T.E (2013) The Productivity Impact of Infrastructure in Turkey, 1987 – 2006, ERSA working paper 333, March.

Forrer, John, James Kee, Kathryn Newcomer, and Eric BoyerForrer, 2010. "Public-Private Partner- ships and the Public Accountability Question". Public Administration Review, Vol. 70, pp. 475-484

Ghali, Khalifa H. (1998) Public investment and private capital formation in a vector error-correction model of growth, Applied Economics, 30:6, 837-844,

Iradian, Garbis (2005) IMF Working Paper Middle East and Central Asia Department Inequality, Poverty, and Growth: Cross-Country Evidence.IMF Working Paper.

Jalilian H, Weiss J (2004) Infrastructure, growth and poverty: some cross-country evidence. Paper prepared for ADB Institute annual conference on 'Infrastructure and Development: Poverty,Regulation and Private Sector Investment', 6 Dec 2004, Tokyo

Jens K. Roehrich, Michael A. Lewis, Gerard George, Are public–private partnerships a healthy option? A systematic literature review, Social Science & Medicine, Volume 113, July 2014, Pages 110-119

Nazlıoğlu,Ş, Özcan, C, Adıgüzel,U and Şahbaz, A. (2014) The Nature of Shocks to Turkish exchange rates: what panel approach says? 03 June 2014, 2nd Economics & Finance Conference, Vienna

Nazlioglu, S., Karul, C. (2015) The Flexible Fourier Form and Panel Stationary Test with Gradual Shifts International Conference on New Trends in Econometrics and Finance Conference, March 23 -28, 2015, Sharjah-Dubai.

Orszag,Peter R. (2009), I Infrastructure: Rebuilding, Repairing and Restructuring, edited by Jason R. Baren, Nova Science Publishers, Incorporated, 2009.

Pereira, Alfredo Marvão and Roca-Sagalés, Oriol (2003) " Spillover effects of public capital formation: evidence from the Spanish regions "Journal of Urban Economics, Volume 53, Issue 2, March, Pages 238-256

Pesaran, M, Shin, Yongcheol and Smith, Ronald, (1997), Pooled Estimation of Long-run Relationships in Dynamic Heterogeneous Panels, Cambridge Working Papers in Economics, Faculty of Economics, University of Cambridge

Pesaran, M. H. (2007), A simple panel unit root test in the presence of cross-section dependence. J. Appl. Econ., 22: 265–312.

Pesaran,, M. Hashem Yamagata, Takashi (2007) Testing slope homogeneity in large panels, Journal of Econometrics, Volume 142, Issue 1, January 2008, Pages 50-93, ISSN 0304-4076, https://doi.org/10.1016/j.jeconom..05.010

Pesaran, M. Hashem ∗,Ullah Aman And Takashi Yamagata (2008) A Bias-Adjusted Lm Test Of Error Cross-Section Independence ,*Econometrics Journal* Volume **11**, Pp. 105–127.

Pesaran, M.H., 2004. General Diagnostic Tests for Cross Section Dependence in Panels.

Sahoo,P.and Dash, (2009) .Infrasturture Development and economic growth in India.Journal of asia Pacific Economy 14:351-365

Salahuddin,, Mohammad and Alam, Khorshed (2015), "Internet usage, electricity consumption and economic growth in Australia: A time series evidence", *Telematics and Informatics,* Volume 32, Issue 4, November 2015, Pages 862-878

Shaleen Singhal , Graeme Newell & Thi Kim Nguyen (2011) The significance and performance of infrastructure in India, Journal of Property Research, 28:1, 15-34

Sahoo, Pravakar and Dash, Ranjan Kumar (2012) Economic growth in South Asia: Role of infrastructure, The Journal of International Trade & Economic Development, 21:2, 217-252.

Sanchez-Robles,B.1998.Infrastuctureinvestment and growth:some empirical evidence. Contemporary Economic policy 16:98-108.