EFFECT OF COASTLINES ON THE TOTAL FACTOR PRODUCTIVITY THROUGH TRANSPORT INFRASTRUCTURE INVESTMENT AND TRANSPORT INFRASTRUCTURE STOCKS

A Thesis Submitted to the Graduate School of Public Policy, The University of Tokyo in partial fulfillment of the requirements for the Degree of Masters in Public Policy/International Program (MPP/IP)

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Thesis Outline

This paper is divided into six major parts: Introduction, Literature Review, Theoretical Framework, Data and Definitions, Empirical Methodology, Main Findings and Summary/Conclusions.

Section 1 gives the general background to the topic and the reasons behind the choice of topic. Also, it states the objectives and gives brief summary of methodologies utilized.

Section 2 reviews the literature on the related fields, in particular in the efficiency of the public investment and transport infrastructure investment as well as the regional disparities due to the geographical location. In this section, related literatures are sorted and briefly analyzed according to several factors. It is sorted in a chronological order and by methodologies employed. Also, it gave overall summary for the general findings.

Section 3 of this paper specifies the reasoning behind the developed models with an aim to connect the model to the theory (Theoretical Framework). First it discusses the theoretical underpinnings of growth theory to generate the growth approach model, later moving to the development of second approach (stock approach) model.

Section 4 presents the descriptive statistics for the used samples (Samples for Developing and Developed countries separately) and provides definitions for the data employed. It also briefly, touches upon the hurdles that were met during the data collection that could have biased the credibility of the findings.

Section 5 consists of Empirical Methodology section. In this section both models are extended from the base model to the final model and some econometrics tests are conducted.

Section 6 is the formal presentation of the findings from this research paper. Results of both approaches and different samples are provided separately.

Finally, Section 7 serves as concluding part of this paper. Summary of the research and conclusion drawn from the findings are presented. Moreover, paper stressed out the some issues faced during this research that can be improved in further research.

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Introduction, Objectives and Summary of Methodologies

Introduction

For the recent three decades there have been numerous researches on the efficiency of infrastructure investment, particularly transport infrastructure investment and infrastructure capital in the need of determining if it really is the factor in the rise of total factor productivity (TFP) and the welfare of people overall. Determining the factors that lead to the growth in TFP is still the biggest question that economists have been asking and been carrying out extensive researches to answer. It is assumed that capital intensity is one of the main determinants of TFP and that policies encourage investment also have a positive impact on TFP growth, including infrastructure investment. But, some economists claim that this effect is only short-term. It is worth mentioning that short-term determinants are proximate, whereas long-term determinants such as trade, integration, institutions, and geography are the main drivers of sustainable growth, according to the growth literature. Following this condition, this paper attempts to analyze the efficiency of in-land infrastructure investment from the different angle, employing geographical factor into the model.

Notion for this assumption comes from the common sense and from the economies of different growth tendencies within the region or country. Historically, until 1800s China and India were counted as the world's advanced countries and they had achieved high growth rates over the centuries. However, if one looks at the state of inland infrastructure it is obvious that it was not well developed, otherwise if it didn't exist. But, the trade between neighboring countries was still existed using the waterways or channels. The Great Silk Road can be the perfect example of how important are the roads or nowadays which we call as transport infrastructure. Cities lied along this road were and have been the hub for the growth in these regions, where other parts are lacked for development. But, later, the development and the expansion of maritime logistics or seaways gave alternatives to countries not to use long and dangerous inland routes; then coastal cities and countries started to boom.

It is definite that from the well-developed transport infrastructure countries benefit vastly. On the supply side, the role of the transport infrastructure can be achieved through two channels. First channel is a direct channel where infrastructure capital stock serves as a production factor through the accumulation of the capital. Also, the investment in transport infrastructure directly boosts the economy. Second channel is an indirect channel, which this paper takes it as a base for the empirical study. Through this channel, increase in infrastructure stock or investment creates positive externality across the range of various economies that could possibly has a larger net effect that goes beyond the initial expectation. These spillover effects can enhance labor productivity by reducing the time wasted on commuting, or by better and faster access to work places, and less costly logistics. From the demand side, improvements in the transport infrastructure give people a chance to have better and faster access to goods and services.

Moreover, one cannot deny the importance of the spatial behavior of the infrastructure investment. Policy makers often face difficulties on the choice of investment on geographical regions to be served. Also, this brings another problem of relocation of new firms or migration in the search for the better or higher quality access. Thus, when we analyze the efficiency and the productivity of the infrastructure investment it is worth employing geographical variables into the model.

In fact, recent empirical studies that follow new economic geography literature have included spatial variables, in particular the variable that corresponds to the accessibility indicator. Deichman, Fay, Koo, and Lall (2002) for Southern Mexico; Lall, Funderburg, and Yepes (2004) for Bazil; Lall, Shalizi, and Deichman (2004) for India; Deichman, Kaiser, Lall, and Shalizi (2005) for Indonesia; and Lall, Sandefur, and Wang (2009) for Ghana found that the accessibility is the main factor behind the productivity of the firms. These examples from the developing countries show that the presence of the high quality transport infrastructure is a key to development.

Objectives

Based on the discussions above, this paper pinpoints the difficulties that inland or land – locked countries face towards the sustainable growth path and it stresses the importance of transport infrastructure facilities comparing to countries with vast coasts, who have an alternative option of waterways. This paper intended to show whether equal budget allocation over the regions of the country is falsified. It also questions ODAs and infrastructure loans and projects provided by international institutions such as IMF, ADB or World Bank, assuming that these multilateral organizations should consider geographical location if the major hypothesis of this paper found to be true. It attempts to show that efficiency of in-land infrastructure stock and investment should be measured in a wider way, taking into consideration of geographical locations of countries. So, main objective of this paper is:

- To see if there is a real difference between efficiency and productivity of infrastructure investment on coastal countries and land-locked countries.

- To see if quantity infrastructure and quality infrastructure stocks add to total factor productivity taking into accounts the geographical locations.

Summary of Methodology

This study employed infrastructure investment growth together with coast to area ratio as an independent variable to the changes in TFP and physical infrastructure quantity and quality density indicators together with coast to area ratio to the TFP level. In the first approach, TFP growth rate of dependency measured as a function of lagged infrastructure investment growth and coast to area ratio that are multiplied by the changes in infrastructure investment. In the second approach, TFP stock is regressed as a function of road density stock together with rail line density stock as quantity infrastructure indicators and paved roads (a percentage of total roads) as a quality measure that are all multiplied by coast to area ratio to see the effect of coastlines.

In the first approach (or growth approach), due to the lack of data for the most developing countries on transport infrastructure investment, investment is taken as a proxy to this value, which may in turn may effect the credibility of the findings of this research paper. Thus, another approach (2^{nd} approach or stock approach) is developed and the model is generated as a caveat to the first approach to confirm the findings of the first model.

From the common assumption that input of additional infrastructure development in advanced countries is marginal and may play insignificant role in TFP growth, this paper focused on developing countries by IMF specification and restricted the model to developing countries. However, to check whether this assumption of common sense matches with empirical data, different sample for advanced countries is created and results are provided in the findings section of this paper.

Meanwhile, to ascertain whether coast to area indicator indeed affects TFP, fixed effects models were defined with the purpose of obtaining the partial effects of infrastructure development – marked by road networks (road density), rail networks (rail line density), paved roads (percentage of total roads) and infrastructure investment.

After outcomes are derived, a dynamic panel model is specified on a country level to examine how TFP in developing countries measured that interacts with real variables and controls along with the lag values of independent variables.

Literature Review

An extensive research has been carried out on the efficiency of infrastructure investment, particularly on transport infrastructure or so called in-land infrastructure. In general, findings of the researches are worrisome as they provide mixed results. Review of literature on current problem did not show a strong evidence of the role of transport infrastructure investment on total factor productivity. Moreover, researches that have been done on the topic of regional disparities do not specify the geographical location, namely effect of coastlines, where mostly mention it as an access to sea. Unfortunately, during the preliminary stage of this paper, not a single research has been found that employs coast to area ratio to the model and checks the effect of the infrastructure investment and infrastructure stocks to overall total factor productivity.

The history of studies analyzing the efficiency and productivity of transport infrastructure investment and infrastructure stock can only go back to few decades. In fact, worldwide high growth period after World War II had been the study period for most researches and academics in any field. If early researches tried to prove the reasoning behind the high growth due to the factor injection, latter papers started to talk about sustainable growth that can be only achieved by the growth in the productivity. Since 1980s, studies on the positive impact of infrastructure on economic growth have started to boost and became one of the hottest topics. Early literatures on studying positive impacts of transport infrastructure are the ones that are carried out by Rodan, Nurkse, Rostow and Hirschman (cited in Li Zhong & Liu Yu (2011)). They employed variety of techniques to analyze the effect of transport infrastructure on economic growth under several theories.

In place with the assumptions on the positive relationship between public investment and productivity, first empirical study by Aschauer (1989) executed to see the relationship between economic growth and infrastructure. The World Bank initiated this project and it was the first empirical study of a kind to see the effectiveness of transport infrastructure investment. In this seminal paper Aschauer (1989) found that the stock of public infrastructure capital is a significant determinant of aggregate TFP.

However, in this paper this hypothesis was not confirmed when this paper employed road stocks, rail lines stocks as a quantity of transport infrastructure and paved roads as a quality transport infrastructure assuming to be the determinants of TFP level (2^{nd} approach model). Also, Holtz-Eakin (1994), Cashin (1995), Baltagi and Pinnoi (1995), and Gramlich (1994) questioned his findings stating the economic significance of his results were deemed implausibly large, and found not to be robust to the use of more sophisticated econometric techniques. Omitted variable bias, reverse causality, heterogeneity and the poor data quality are the common errors, that may have biased the findings.

Furthermore inspired by Aschauer methodology, Holtz – Eakin (1994) and Barro (1995) further developed this approach by separating transport infrastructure investment from total investment. They estimated the impact of infrastructure capital to economic growth separately by using the method of production function. This method was quite popular among researchers. In fact, studies by Aschauer (1989), Munnell (1990), Hulten,Schwab (1991), Merriman (1990), Christodoulakis (1993), Wylie (1995), Denny,Kevin (1997), Everaert, Heylen (2001) use the part of the production function method, to work out the considerable flexibility by using time series data. In general their findings show relatively similar results showing the positive relationship between transport infrastructure investment and growth.

Furthermore, findings of some papers somehow show more accurate results on the effectiveness of transport infrastructure investment and output as they employ Panel sample data. Below stated empirical analysis consider the regional effects and employ spatial econometrics models. Munnell (1990), Moonaw, Williams (1991), Garlino,Voith (1992), Evans,Karras (1994), Nourzad, Vrieze (1995), Bonaglia, Ferrara (2000) employed micro level panel infrastructure investment data on state and county level. They found that level of output elasticity of state/county is much smaller than the national level showing the regional effects of transport infrastructure investment. This may be reasoned by the dropping out of the positive spillover effects among regions when estimating in country level.

Spillover effects on infrastructure are studied by many scholars using variety of techniques such that Boarnet (1998) and Schwartz (1995) on the basis of the Holtz-Eakin and Schwartz (1995) modeling found there was a negative spillover effect of the road infrastructure to economic growth. Holtz-Eakin and Schwartz (1995) model employed the spatial matrix connecting production function to infrastructure variables, where other most econometric techniques used mostly concentrate on the mathematical exposition.

But, several researches found positive relationship between some form infrastructure investments and stocks to productivity growths. Such as Nadiri (1996) found that highways contribute largely to the TFP growth but effects are relatively short lived. This finding was also confirmed by Fluente (2010) stating that return on infrastructure is high on early stages and falls sharply thereafter. Mendes, Teixeira and Salvato (2008) claimed that decrease in infrastructure investment in early 1980s in Brazil resulted the drop in the profitability and competitiveness of firms, leading to decrease in private investments and the fall in GDP. Moreover, Rodrik and Subramanian (2004) analyzed the high growth period in India before liberalization, namely period from 1980-1990, found that this growth was mainly accounted for the increase in the public investment, which might have been a fundamental for the high growth after the liberalization since 1991.

Estache and Fay (2009) pinpoint some interesting viewpoint on literature claiming the positive relationship of infrastructure – growth nexus. Understanding that the connection between infrastructure and growth appears to vary across countries and over time as well as within countries and within sector themselves, authors suggest that increasing empirical agreement exists regarding the growth – enhancing effect of infrastructure. For instance, in a review of evidence produced by Romp and de Haan (2005), 32 of 39 studies on OECD countries find a “positive effect of infrastructure only on some combination of output, efficiency, productivity, private investment, and employment.” Moreover, 9 of 12 studies on developing countries indicate a significant positive impact of increase in public expenditure, particularly, increase in overall infrastructure investment (Estache and Fay 2009). But these sources don't show clear effect of transport infrastructure investment.

In this context, it is important to highlight the various transmission mechanisms through which infrastructure affects growth. Referring back to the seminal literature on this topic, Aschauer (1989) and Barro (1990) described that public infrastructure investments enhance private sector productivity further accelerating the growth in TFP. Aschauer's claim on the productivity slowdown to the lack of infrastructure investment in 1970's in US captures the idea that an increase in public capital stock (relative to private capital) has a positive but decreasing impact on the marginal product of all factor inputs (such as capital and labour). Hence, the cost of production inputs falls and the level of private production increases. As Agenor and Moreno-Dodson (2006) point out, "this scale effect on output may lead, through the standard accelerator effect, to higher private investment – thereby raising production capacity over time and making the growth effect more persistent."

However, the recent IMF working paper (Buffie et al 2015) claims that the effect of additional investment spending on the growth rate of output doesn't depend on the level of efficiency. They highlight that the invariance result they found is not a technical detail; rather, it speaks to different ways of thinking about public investment and development. One approach emphasizes the need to spend resources where they can be used well. Another emphasizes the need to invest where the need is greatest. So, maintaining the quality of public infrastructure may positively affect on growth by improving the durability of private capital. That is, increasing government infrastructure maintenance spending allows the private sector to spend less to maintain its own capital and thus to allocate its investment capacity to other uses, thereby generating an additional growth effect (Dissou and Didik (2013)). And they claim that this effect is confused as an effect of the infrastructure investment, proving our statement that infrastructure investment has indirect effect, but not direct.

But improvement in the public infrastructure, particularly transport infrastructure facilities, benefits the economy indirectly, through the growth in productivity. For example, better transport infrastructure facilities found to improve access to healthcare and education. Through this effect, overall impact of infrastructure impact is magnified (Agenor and Moreno-Dodson 2006). Moreover, Agenor and

Moreno-Dodson (2006) added the labor productivity as another channel that is affected by the better infrastructure. Better access to infrastructural facilities means that workers can get to their jobs more easily and perform their job-related tasks more rapidly. Other studies have also found evidence of various positive externalities induced by public infrastructure, including increased competitiveness, greater regional and international trade, expanded FDI, and finally higher profitability of domestic and foreign investment flows which raise investment ratios and boost growth in per capita income (Fourie 2006; Fedderke et al. 2006; Richaud et al. 1999).

As the reader has already had some idea on the mixed findings and various methodology employment of several literatures in chronological order, none of them could confirm solidly the effect of transport infrastructure investment and stocks on the sustainable economic growth or growth in TFP. Even the ones who confirm the significance of infrastructure overall, they assume some important conditions and add some control variables.

As a conclusion to the literature review on this topic, the research conducted by Melo, Graham, Brage-Ardao (2013) that utilized the meta – analysis of empirical evidence (563 estimates from 33 papers) on productivity of transport infrastructure and found that 10% increase in transport infrastructure results 0.5% increase in output. This summary of the papers showed that there is a positive relationship between infrastructure investment and the sustainable economic growth through the growth in total factor productivity. This claim is fulfilled by this paper's findings as well (1st approach – growth approach).

Theoretical Framework, Growth Approach, Stock Approach

In this section, paper provides a brief review of the economic theory underlying the growth accounting, in particular TFP growth and TFP residual stock approaches to transport infrastructure evaluation, both to provide a background for the interpretation of the ensuing empirical analysis, and to highlight relationship, pitfalls and opportunities of the alternative models.

First Approach (Growth approach)

As it will be fully described in the data section, TFP growth figures are obtained form the Penn World Table. Assuming transport infrastructure investment (which is a flow variable) together with coast to area ratio as a function of TFP, change in the TFP level (so called TFP growth) has been used in this approach.

Modeling infrastructure investment as a flow variable first met from Barro (1990), where he models infrastructure in the context of a simple AK endogenous growth model. Actually, in all growth accounting literature the starting point is a production function that links real inputs to real output, under the assumption that factor remuneration equals their marginal product. With these hypotheses it is relatively straightforward to derive total factor productivity, and the question of the interest is whether TFP can be at least in part explained by changes in the pattern of infrastructure investment, particularly transport infrastructure investment.

Let us define the factor inputs labor and capital L and K, while Y denotes gross output. Inputs are transformed into output according to the production function,

$$Y = AF(K, L) \qquad (1)$$

where A indicates Hicks neutral technological progress. Under the hypothesis of profit maximizing behavior and competitive markets, the growth rate of A is

$$\Delta A = \Delta Y - \alpha\Delta L - \beta\Delta K \qquad (2)$$

with α and β being output shares of labor and capital. With constant returns to scale, the sum of α and β is equal to 1. All the terms in the right hand side of the equation (2) are known, and can be used to measure the growth in the index of technological progress, delta A (ΔA) is usually referred to as TFP growth. Luckily, due to the availability of data on the residual and TFP growth, this paper didn't attempt to estimate, rather took it as given.

To see more details from standard production function, Cobb-Douglas production function are further assumed with factor inputs.

$$Y = A * K^{\alpha} * L^{1-\alpha} \qquad (3)$$

$$Y = \tilde{A} * K^{\alpha} * K_{inf}^{\beta} * L^{1-\alpha-\beta} \qquad (4)$$

$$A = \tilde{A} * K_{inf}^{\beta} * R_{coast} \qquad (5)$$

As it is mentioned earlier, this paper assumed transport infrastructure and the coastline as a function of TFP

$$A = f\left(K_{inf}, R_{coast}\right) \quad (6)$$

Being infrastructure investment as a flow variable this assumption has been changed to following, which takes care of other factors those effects to TFP by $A_t - A_{t-1}$.

$$\Delta A = f\left(K_{inf}, R_{coast}\right) \quad (7)$$

From this assumption, following baseline model is generated.

$$A_{j,t} - A_{j,t-1} = \alpha_j + \theta * GDPper\ capita_{j,t-1} + \beta \Delta K_{j,t-1}^{inf} + \gamma \left(\frac{Coast}{Area}\right)_j + \delta \left[\Delta K_{j,t-1}^{inf} * \left(\frac{Coast}{Area}\right)_j\right] + \epsilon_{j,t} \quad (8)$$

Following the above argument, the effect of coastline and transport infrastructure investment can be evaluated on the basis of the sign and significance of the coefficient of interaction value (δ - coast/area ratio*infrastructure investment). In a regression of ΔA, GDP per capita at time *t*, lagged transport infrastructure investment, Coast/Area ratio value, and interaction value are computed from (8). From now on paper refers to this approach as growth approach or 1st approach.

Second Approach (Stock approach)

As a caution due to the lack of transport infrastructure investment data in the 1st approach, the second approach from the stock values is generated and empirical findings provided to check whether the results of the 1st approach is credible. In the meantime it is worth mentioning that modeling infrastructure as a stock variable can been seen from Futagami et al. (1993) assuming government spending does not influence the aggregate production function directly, but only indirectly via the stock of public capital, for example, infrastructure stocks. This paper also uses assumption that transport infrastructure stocks are the main determinants of the overall TFP level and takes total factor productivity as a function of transport infrastructure stocks and the coastlines.

$$A = f\left(K_{road\ density}, K_{rail\ line\ density}, M_{paved\ roads}, R_{coast}\right) \quad (9)$$

However, one may question that productivity may be caused by other several factors, which some of them are stated in the above methodology section. There is a big hardship on the collection of these data from developing countries due to unavailability. This paper attempted to see whether there is a relationship between infrastructure investment and infrastructure stock to total productivity, thus adding other variables assumed that may not shift current findings sharply that are provided below in the main findings section.

Availability of the data on residual value (TFP value), road and rail line density value as a quantity measure of infrastructure and paved road statistics as a quality measure together with lengths of coasts gave this paper another chance to test whether effect is significant in provided sample.

From given assumption, the base model is generated as follows:

$$\begin{aligned} A_{j,t} = \alpha_j + \theta GDPpercapita_{j,t} + \beta_1 K_{j,t}^{road\ density} + \beta_2 K_{j,t}^{rail\ line\ density} \\ + \beta_3 K_{j,t}^{paved\ roads} + \gamma \left(\frac{coast}{area}_j\right) + \delta_1 \left(K_{j,t}^{road\ density} * \left(\frac{coast}{area}_j\right)\right) \\ + \delta_2 \left(K_{j,t}^{rail\ line\ density} * \left(\frac{coast}{area}_j\right)\right) \\ + \delta_1 \left(K_{j,t}^{paved\ roads} * \left(\frac{coast}{area}_j\right)\right) + \epsilon_{j,t} \end{aligned} \quad (10)$$

Following above model the effect of coastline and transport infrastructure stocks can be evaluated on the basis of the sign and significance of the coefficient of interaction value (δ - coast/area ratio*infrastructure stock). In a regression of A, GDP per capita at time *t*, infrastructure quantity in the form of road density and & rail line density, infrastructure quality in the form of paved roads, Coast/Area ratio value, and interactions values computed from (10). From now on paper refers to this approach as stock approach or 2nd approach.

Data and Definitions, Descriptive Statistics

Data and Definitions

Sample

Both models from different approaches have two different samples, for developing and developed countries separately. Time range for developing countries lies between 1993-2011 and for developed countries lies between 1995-2013 in 1st approach and 1993-2013 for developed and 1993-2011 for developing countries.

For the 1st approach, there are 31 developed countries and 80 developing countries. For the 2nd approach, there are 29 developed countries and 52 developing countries.

1st Approach Statistics:

Table 1: Descriptive Statistics of Sample 1 (1st Approach)

Variable	Obs	Mean	Std. Dev.	Min	Max
Country	0				
Year	580	2003	1991.034	1995	2013
Gdpgrowth	572	2.530	3.247	-14.814	11.799
Gdppercapita	580	31805.8	19724.6	1857.7	115109.3
Tfpgrowth	570	0.497	2.494	-13.006	14.988
Inf % of gdp	580	0.924	0.421	0	2.3
Invgdp % of gdp	580	23.667	4.313	11.766	40.051
coast/area	580	54.369	142.966	0	800
country1	580	16.067	8.972	1	**31**

Table 2: Descriptive Statistics of Sample 2 (1st Approach)

Variable	Obs	Mean	Std. Dev.	Min	Max
country	0				
year	1519	2002.006	5.476	1993	2011
gdpgrowth	1512	4.407	5.230	-30.9	62.2
gdppercapita	1514	3822.057	5647.883	100.448	44313.59
tfpgrowth	1478	1.009	5.069	-31.591	88.346
infinvst	1510	22.904	7.380	-1.75	72.408
coast/area	1519	20.269	52.037	0	261
country1	1519	40.477	23.090	1	**80**

2nd Approach Statistics:

Table 3: Descriptive Statistics of Sample 1 (2nd Approach)

Variable	Obs	Mean	Std. Dev.	Min	Max
Country	0				
Year	407	2003.145	5.175	1993	2013
Paved roads	407	80.128	23.594	17.4	100
Road density	407	122.336	89.101	6.6	504.5
Rail line density	405	4.763	3.162	0	12.1
GDP per capita	407	32839.2	11376.2	9876.5	64864.6
Coast/Area	407	35.056	46.914	0	172
GDP growth	407	2.693	3.216	-14.814	11.799
TFP	407	0.551	2.568	-13.006	12.529
Country 1	407	14.439	8.316	1	**29**

Table 4: Descriptive Statistics of Sample 2 (2nd Approach)

Variable	Obs	Mean	Std. Dev.	Min	Max
Country	0				
Year	666	2001.811	5.488493	1993	2011
Paved roads	666	52.497	31.207	6.3	100
Road density	666	44.715	50.349	0.4	216
Rail line density	664	1.851	2.413	0	12.1
GDP per capita	666	9787.201	9220.256	454.7	64104.5
Coast/Area	666	10.928	25.157	0	122
GDP growth	666	4.499	5.480	-30.9	62.2
TFP	662	1.180	5.623	-21.672	88.346
Country 1	666	26.799	13.797	1	**53**

Data on TFP value, TFP growth and GDP per capita

This data is collected from several sources for both sets of samples. Data on TFP value is collected form Penn World Table, where data on TFP growth and GDP per capita have been collected from IMF website. Due to the lack of data for certain countries from Penn World Table, TFP growth figures obtained from IMF web site are transformed to the level value and employed in the model.

Data on Transport Infrastructure Investment

According to the OECD, "Infrastructure investment covers spending on new transport construction and the improvement of the existing network. Infrastructure investment is a key determinant of performance in the transport sector. Inland infrastructure includes road, rail, inland waterways, maritime ports and airports and takes account of all sources of financing. Efficient transport infrastructure provides economic and social benefits to both advanced and emerging economies by: improving market accessibility and productivity, ensuring balanced regional economic development, creating employment, promoting labor mobility and connecting communities". Under this definition this paper attempted to gather data that fits the specifications mentioned in the definition.

As this paper divided its sample into two categories (Developed countries and Developing countries), the data sources are different. Data on in-land infrastructure (or transport infrastructure investment) are collected from OECD web site for the time period of 1995-2013 for developed countries. For developing countries, data only for 15 countries are found from OECD website in the 1993-2011 range and other data for 28 countries are collected from the national accounts and from Bloomberg information terminal.

The search for the data from other remaining developing countries took an extensive scale starting from all multilateral organizations, private and public statistics databases to national accounts and tried to employ several strategies. Some developing countries that don't separate the infrastructure investment into categories and report only aggregated infrastructure, paper attempted to assign the some portion of total infrastructure spending for all developing countries. But, this strategy couldn't be further employed, because some developing countries don't even report separate aggregated infrastructure investment, report only public investment data. Later, it is attempted to look at the policy papers and transport infrastructure policies and individually set the share of transport infrastructure investment from the total spending. However, obtained data based on this strategy did not match the data for the some countries that reported their transport infrastructure investment data. Thus, this paper chose the public investment as a proxy to the transport infrastructure investment as an investment indicator to avoid subjective approach to collect and generate data, similar to IMF working paper by Senevirathe & Sun (2013) in assessing the transport infrastructure investment.

Data on road density, rail road density and paved roads

Luckily, these variables are collected form "Knoema" data bank, but highly imbalanced. They refer to the World Bank (data is not available anymore), IRF (International Road Federation) (costly to collect), and IUR (International Union of Railways) as a main source of the data provided.

According to the above stated websites, definitions are as follows:
Paved road data shows "the share of roads surfaced with crushed stone (macadam) and hydrocarbon binder or bituminized agents, concrete or cobblestones, expressed as a percentage of the length of all roads. Total paved roads divided by the total road network." Source: WDI. Road data comes from the International Road Federation. This indicator in the model denotes the quality of infrastructure, which adds to the TFP of the country as a whole.

Road Density indicates "total road network includes motorways, highways, main or national roads, secondary or regional roads, and all other roads measured in kilometers in a country. Total road network divided by the land area." Source: WDI. Road and passenger car data come from the International Road Federation, World Road Statistics.

Rail line density denotes "The length of rail lines divided by the land area expressed in 1,000 kilometers. Rail lines are the length of railway route available for train service measured in kilometers, irrespective of the number of parallel tracks." Source: WDI. Railway data come from the International Union of Railways. Road and passenger car data come from the International Road Federation, World Road Statistics.

Data on Coast/Area ratio

This data is collected from The World Fact book that covers 198 countries and 55 territories, form the book published by the Central Intelligence Agency. In addition to coastline lengths, this is the source of the land area used to calculate the “coast/area ratio”. This ratio measures how many meters of coastline correspond to every square kilometer of land area (m/km^2). The ratio illustrates the ease of accessibility to the country's coast from every point in its interior. This value is incorporated in the model as a control variable, a dummy variable and also it comes with interaction with of main indicators such as transport infrastructure investment, road density, rail line density, and paved roads.

Empirical Methodology, Choice of the Model, Parameter Specifications

1st approach

As the base model is specified above (equation 8), δ captures the effect of infrastructure investment together with coastal length to overall productivity. However, estimation of this equation that do not control for specific effects may be subject to a sort of Endogeneity bias reflecting the *reverse causation* from TFP to transport infrastructure investment. So, generally speaking the standard solution for this problem is to turn to panel data techniques in order to control for unobserved national or regional effects. One possibility is to estimate a *fixed effects model*, which this paper attempted to do. In fact, later in this section appropriate statistic test has been carried out to prove on the choice of model.

Also, this involves introducing dummy variables in order to estimate a different regression constant for each country. Thus, the dummy is introduced in the model in place with coast/area ratio, where it’s equal to 1 if coast/area ratio is above 0, otherwise 0. This transformed model below denotes the base model for the empirical analysis.

$$A_{j,t} - A_{j,t-1} = \alpha_j + \beta_1 GDPper\ capita_{j,t-1} + \beta_2 \left(\frac{coast}{area_j}\right) + \beta_3 \Delta K^{inf}_{j,t-1} + \gamma d + \epsilon_{j,t} \qquad (11)$$

Further, as a goal of this paper to find whether weight of infrastructure investment in coastline countries and land – locked countries differs in overall productivity growth, interaction value has been introduced into the model.

$$A_{j,t} - A_{j,t-1} = \alpha_j + \beta_1 GDPper\ capita_{j,t-1} + \beta_2 \Delta K_{j,t-1}^{inf} + \beta_3 \left(\frac{coast}{area_j}\right)$$

$$+\delta\left(\frac{coast}{area_j} * \Delta K_{j,t-1}^{inf}\right) + \gamma d + \epsilon_{j,t} \qquad (12)$$

After transformation of base model into the above stated extended model, empirical regressions has been carried out. To see whether this model has random effects, Breusch and Pagan Lagrangian multiplier test for random effects carried out. The results show in the below table characterize the random effects and OLS regression is not suitable in our give model.

Table 5: Breusch and Pagan Lagrangian multiplier test for random effects

tfpgrowth[country1,t] = Xb + u[country1] + e[country1,t]			
Estimation results:			
		Var	sd = sqrt (Var)
	tfpgrowth	23.341	4.831
	e	20.551	4.533
	u	1.473	1.214
Test:	Var(u) = 0		
		chibar2(01) =	56.69
		Prob>chibar2 =	0.0000

To test for the cross-sectional dependence or contemporaneous correlation using Breusch-Pagan LM test of independence performed. The null hypothesis of Breusch-Pagan LM test of independence is that residuals across countries are not correlated. In our model Pr=0.1161 denoting that there is no cross-sectoral dependence across countries. In fact, this proves the claim that cross-sectional dependence is a problem in macro panels with long time series (20-30 years). This is not much a problem in micro panels (few years and large number of cases) as in this case.

In the final models both random and fixed effects specification are considered to get the better picture. As, both, random and fixed models are to control for the possible existence of specific effects have their own advantage and disadvantages.

The main shortcoming of the fixed effects model is that it ignores most of the information contained in the cross-section variation of the data. When we employ this specification we are essentially estimating the production function with the variables measured in deviations from their average values for each country (taken over the entire sample period). As a result, the parameters are identified by the variation over time of TFP and its determinants in the different countries.

The random effects model, on the other hand, does make use of the cross-sectional variation in the data but it has the important disadvantage that if the specific effects are correlated with the regressors, as it happened in our regressions, the estimation will yield unreliable results (the coefficient estimates will be inconsistent). To check which specification is better, this paper used Hausman test, which is basically a test of the hypothesis that the specific effects and the regressors are uncorrelated (Table 6).

Hausman test puts the random effects as a null hypothesis and fixed effects as alternative. At this point we reject the null hypothesis, as a result of our test and employ fixed effects models as an appropriate one.

Table 6: Hausman Test (1st Approach, Sample 2)

	---- Coefficients ----			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	Random Effects Model	Fixed effects model	Difference	S.E.
-lagged GDP per capita	-0.0003	-0.0001	-0.00021	0.00005
-Δinf.investment lagged	-2.585	-1.912	-0.673	0.198
-inter*	0.114	0.081	0.032	0.017

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: difference in coefficients not systematic

chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
37.94
Prob>chi2 = 0.0000

*inter=coast/area ratio*Δinf.investment lagged

Referring to the choice of our model, Fixed Effects model is regressed (Table 19). Further to check whether proposed model best suited model for the analysis test for the heteroskedasticity has been carried out (Table 7). Modified Wald test for groupwise heteroskedasticity in fixed regression model rejects the Null hypothesis of homoscedasticity (or constant variance). It represents the presence of heteroskedasticity in the model.

Table 7: Modified Wald Test for Groupwise heteroskedasticity in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i	
chi2 (80) =	27429.57
Prob>chi2 =	0.0000

Therefore, to obtain heteroskedasticity-robust standard errors, fixed effects model with robust standard error specification is executed (Table 20). As it can be seen from the model α_j denotes the country fixed effects in this model. Using statistics software above stated steps followed and lead to the execution of final fixed effects model and additionally robust standard errors obtained. Finally, this paper uses Arellano-Bond dynamic panel techniques. In the main findings section, results will be provided to compare between the specifications of the models.

Hence, interpretation of the variables, parameters and coefficients are as follows:

Dependent Variable

ΔA $(A_{j,t} - A_{j,t-1})$ – represents the change in the productivity growth, which in this model assumed that to be from the investment in transport infrastructure investment

Independent Variables

$GDPper\ capita_{j,t-1}$ – represents the GDP per capita for specified country at the time *t – 1* in current prices in USD

$\Delta K_{j,t-1}^{inf}$ – represents the change in the in-land infrastructure investment in country j at t-1.

$(\frac{coast}{area_j})$– represents ratio of a country j.

$\frac{coast}{area\ j} * \Delta K_{j,t-1}^{inf}$ – represents the weight of the transport infrastructure investment growth and the coast to area ratio in country j at time t-1.

d – represents the dummy variable in this model. It is equal to if the coast to area ratio of the country is greater than 0 and it equal to 0 otherwise.

Coefficients

α_j – denotes the fixed value of a country, defining its unique characteristics.

β_1 – denotes how income in terms of GDP per capital from previous period effects the total factor productivity.

β_2 - denotes the change in productivity due to a change in investment.

β_3 - denotes the change in productivity for country j.

δ - denotes the change in productivity due to a change in investment in coastal country

γ - denotes the productivity difference of coastal area country to inland country.

2nd approach

After the base model is specified above, the dummy is introduced in the model, where it's equal to 1 if coast/area ratio is above 0, otherwise 0. This transformed model below denotes the base model for the empirical analysis.

$$A_{j,t} = \alpha_j + \theta GDPpercapita_{j,t-1} + \beta_1 K_{j,t-1}^{road\ density} + \beta_2 K_{j,t-1}^{rail\ line\ density} + \beta_3 K_{j,t-1}^{paved\ roads} + \beta_4 \left(\frac{coast}{area\ j}\right) + \gamma d + \epsilon_{j,t} \quad (13)$$

Further, as a goal of this paper to find whether the productivity of accumulated infrastructure stock in coastline countries and land – locked countries differs in overall productivity growth, interaction value has been introduced into the model.

$$A_{j,t} = \alpha_j + \theta GDPpercapita_{j,t-1} + \beta_1 K_{j,t-1}^{road\ density} + \beta_2 K_{j,t-1}^{rail\ line\ density} + \beta_3 K_{j,t-1}^{paved\ roads} + \vartheta\left(\frac{coast}{area}_j\right) + \delta_1\left(K_{j,t-1}^{road\ density} * \left(\frac{coast}{area}_j\right)\right) + \delta_2\left(K_{j,t-1}^{rail\ line\ density} * \left(\frac{coast}{area}_j\right)\right) + \delta_1\left(K_{j,t-1}^{paved\ roads} * \left(\frac{coast}{area}_j\right)\right) + \gamma d + \epsilon_{j,t} \quad (16)$$

After transformation of base model into the above stated model, empirical regressions have been carried out. Even though final model already shows the fixed effects specification from the initial stage, Breusch and Pagan Lagrangian multiplier test confirmed the presence of random effects. The results show in the below table characterize the random effects and OLS regression is not suitable in our given model. Null hypothesis of OLS is rejected in this test, where random effects are alternative.

Table 8: Breusch and Pagan Lagrangian multiplier test for random effects

tfpgrowth[country1,t] = Xb + u[country1] + e[country1,t]

Estimation results:

	Var	sd = sqrt (Var)
tfpgrowth	32.989	5.743
e	26.903	5.186
u	12.784	3.575

Test: Var(u) = 0

chibar2(01) =	13.25
Prob>chibar2 =	0.0001

To test for the cross-sectional dependence or contemporaneous correlation using Breusch-Pagan LM test of independence performed. The null hypothesis of Breusch-Pagan LM test of independence is that residuals across countries are not correlated. In our model Pr=0.1018 denoting that there is no cross-sectoral dependence across countries. In fact, this proves the claim that cross-sectional dependence is a problem in macro panels with long time series (20-30 years). This is not much a problem in micro panels (few years and large number of cases).

Further, to choose between the Random and Fixed Effects Model Hausman test is carried out (Table VIII). Hausman test puts the random effects as a null hypothesis and fixed effects as alternative. At this point this paper was not able to reject the null hypothesis. However, one should feel the caveat in this test as the result may be biased due to the mismatch in the matrix of coefficients being tested. This problem occurred due to the data inconsistency because of the highly unbalanced panel data across the countries and years.

Table 9: Hausman Test (2nd Approach, sample 2)

Note: the rank of the differenced variance matrix (6) does not equal the number of coefficients being tested (7); be sure this is what you expect, or there may be problems computing the test. Examine the output of your estimators for anything unexpected and possibly consider scaling your variables so that the coefficients are on a similar scale.

	---- Coefficients ----			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	Fixed effects	Random Effects	Difference	S.E.
lagged gdppc	-0.001	-0.000	-0.000	0.000
road density	0.001	-0.006	0.007	0.016
rail line density	0.647	0.609	0.037	1.895
paved roads proportion	-0.019	-0.007	-0.013	0.028
road density*(coast/area)	-0.002	0.001	-0.002	0.002
rail density*(coast/area)	-0.056	-0.029	-0.026	0.117
paved roads*(coast/area)	0.001	0.002	-0.001	0.001

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: difference in coefficients not systematic
chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 4.96
Prob>chi2 = 0.5486

To continue further from the same procedure for both approaches, fixed effects model is regressed even though Hausman test could not reject the random effects. Referring to the choice of our model, Fixed Effects model is regressed (Table 28). Further to check whether proposed model best suited model for the analysis test for the heteroskedasticity has been carried out (Table 10). Modified Wald test for groupwise heteroskedasticity in fixed regression model rejects the Null hypothesis of homoscedasticity (or constant variance). It represents the presence of heteroskedasticity in the model.

Table 10: Modified Wald test for groupwise heteroskedasticity in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i	
chi2 (80) =	18468.61
Prob>chi2 =	0.0000

Therefore, to obtain heteroskedasticity-robust standard errors, fixed effects model with robust standard error specification executed. As it can be seen from the model α_j denotes the country fixed effects in this model. Using statistics software above stated steps followed and lead to the execution of final fixed effects model and additionally robust standard errors obtained. Finally, this paper uses Arellano-Bond dynamic panel techniques. In the main findings section, results will be provided to compare between the specifications of the models.

Hence, interpretation of the variables, parameters and coefficients are as follows:

Dependent Variable

$A_{j,t}$– represents the residual value in country j at time t, which in this model assumed that this value is determined from the existing accumulated road length and rail line density as a physical infrastructure and from the indicator of paved roads as a quality value effecting to productivity of the economy.

Independent Variables

$GDPper\ capita_{j,t-1}$ – represents the GDP per capita for specified country at the time *t – 1* in current prices in USD

$K_{j,t-1}^{road\ density}$ – represents the total road network divided by the area in country *j* at *t-1*.

$K_{j,t-1}^{rail\ line\ density}$ – represents the total rail line network divided by the area in country *j* at *t-1*.

$K_{j,t-1}^{paved\ roads}$ – represents the total paved roads divided by the total road network in country *j* at *t-1*.

$\left(\frac{coast}{area}_j\right)$– represents the ratio of coast length of a country j to its area.

$K_{j,t-1}^{road\ density} * \left(\frac{coast}{area}_j\right)$– this interaction value represents the weight of the total road network and the coast to area ratio in country j at time t-1.

$K_{j,t-1}^{rail\ line\ density} * \left(\frac{coast}{area}_j\right)$– this interaction value represents the weight of the total rail line network and the coast to area ratio in country j at time t-1

$K_{j,t-1}^{paved\ roads} * \left(\frac{coast}{area}_j\right)$– this interaction value represents the weight of the paved roads network and the coast to area ratio in country j at time t-1

d – represents the dummy variable in this model. It is equal to if the coast to area ratio of the country is greater than 0 and it equal to 0 otherwise.

Coefficients

α_j – represents the fixed value, which shows the varying factors across countries but are time invariants, hence the fixed effects.

θ – represents how income in terms of GDP per capital from previous period effects the total factor productivity.

β_1 - represents the change in productivity due to a change in road density in inland country

β_2 - represents the change in productivity due to a change in rail line density in inland country

β_3 - represents the change in productivity due to change in paved road proportion in inland country

ϑ- represents the weight of productivity to its geographical location

δ_1 - represents the change in productivity due to a change in road density in coastal country

δ_2 - represents the change in productivity due to a change in rail line density in coastal country

δ_3 - represents the change in productivity due to a change in paved roads share in coastal country

γ - represents the productivity difference of coastal area country to inland country.

Main Findings

In this section the results of empirical analysis are presented. Following the two approaches that are mentioned above, models are specified and results are estimated. Results for the two different samples will be shown separately.

1st approach – Sample 1 (Advanced Countries)

In this sample 31 advanced countries indicators are regressed in our proposed model (See Descriptive Statistics Table I). In this sample the results of the empirical analysis are provided to see whether the initial assumption of which the efficiency of the additional infrastructure investment is very small in developed countries. According to the results obtained using the empirical analysis, the assumption is confirmed that the interaction between the coast to area ratio and the transport infrastructure investment is insignificant in total factor productivity growth in both fixed and random effects with robust standard errors. The results obtained are provided below using random effects and country fixed effects with robust standard errors (Table 11).

Table 11: Results (1st Approach, Sample 1 - Developed countries)

Variable	Random Effects Model (Robust Standard Errors)	Fixed Effects Model (Robust Standard Errors)
lagged gdppc	-.000043***	-.000049***
Δinf.investment lagged	-0.814*	-1.110*
coast/area ratio	-2.15E-03	.630***
inter*	**0.003**	**0.005**
dummy	-0.348	(omitted)
_cons	2.044***	-30.420***
Observations	569	569
R-squared		0.084
Adjusted R-squared		0.078

Legend: * p<0.10; ** p<0.05; *** p<0.01
*inter=coast/area ratio*Δinf.investment lagged

It is interesting to see that; the change in the transport infrastructure investment is negatively correlated with the growth in Total Factor Productivity in developed countries. In modern literature this relationship is found in several researches. Such as Montolio &Sole-Olle (2009) found that marginal road infrastructure investment has a negative effect on the growth rate of TFP and this effect is stronger in regions with a vehicle-intensive sectorial structure. From this research outcome we can characterize developed countries as the regions with a vehicle-intensive structure. Moreover Ford & Poret (1991), found significant positive relationship between infrastructure investment and TFP, but found infrastructure elasticity to TFP growth of -0.6.

Following the methodology of this paper, first base model is generated as TFP growth to be the function of change in the infrastructure investment, GDP per capita of previous period and the dummy variable created if the country has a coast or not. Furthermore, interaction value of coast to ratio to the change in the transport infrastructure model is employed in our model. Results of the both specification Random and Fixed effects model in the extended model with and without robust standard errors are provided in the Appendix of this paper (Table

15, Table 16, Table 17, Table 18), which the aggregated results shown above in Table 11.

1st approach – Sample 2 (Developing Countries)

In this sample 80 developing countries under the specification of IMF are analyzed in our proposed model (See Descriptive Statistics Table II above). As this sample to be this paper's main objective, results are provided under necessary statistical tests that were shown in empirical methodology section. Following table presents the aggregated results of the empirical evidence. For separate findings please refer to Appendix (Table 19, 20, 21, 22, 23)

Table 12: Results (1st Approach, Sample 2 - Developing Countries)

Variable	Random Effects Model (Robust Standard Errors)	Fixed effects (FE) Model (Robust Standard Errors)	OLS (absorbing country fixed effects) - Robust Standard Errors
lagged gdppc	-.0001**	-.0003***	-.0003***
Δinf.investment lagged	-1.912**	-2.585**	-2.585***
coast/area ratio	-0.002	(omitted)	(omitted)
inter*	.080*	**.113****	.113***
dummy	-3.192***	(omitted)	(omitted)
_cons	8.395***	8.056***	8.056***
Observations	1399	1399	1399
R-squared		0.042	0.171
Adjusted R-squared		0.040	0.119

legend: * p<.1; ** p<.05; *** p<.01
*inter=coast/area ratio*Δinf.investment lagged

Results obtained above reject the null hypothesis that this paper set at initial level. It shows that increase in the infrastructure investment in coastal countries, actually supports the growth in total factor productivity by 0.08 in the 1 unit increase. But, if you look at the dummy variable created, the parameter denotes -3.19 in random effects model, stating the longer coastal lines has negative effect on TFP growth. Also, the change in the transport infrastructure investment negatively correlated to the TFP rise. Moreover, increase in the GDP per capita negatively affected the growth in TFP.

Following the statistical test performed in the empirical methodology section of this paper, to obtain heteroskedasticity-robust standard errors fixed effects model with robustness check is regressed and findings are presented in above table. Furthermore, robust dynamic panel-data estimation using Arellano-Bond estimates has been carried out to see the lagged value effects (Table 24). According to the regressed parameters effect of TFP growth for the next period is short lived. It only shows positive significance in one period lagged but becomes insignificant after second period. Previous years GDP per capita level has a negative relationship in TFP growth in our model for developing countries, which we can say that economic growth doesn't necessarily mean sustainable growth. Also, increase in infrastructure investment results in the negative TFP growth, however coefficient that leads to this value is very small. In addition to this findings increase in the one unit of infrastructure investment in coastal line countries results in a 0.21 unit of TFP growth, still rejecting our main hypothesis of higher efficiency in transport infrastructure investment in-land countries comparing to coastal countries.

2nd approach – Sample 1 (Advanced Countries)

In this sample 29 advanced countries indicators are regressed in our proposed model (See Descriptive Statistics Table III). In this sample the results of the empirical analysis are provided to see whether the initial assumption of which the efficiency of the additional infrastructure capital or stock is very small in developed countries. According to the results obtained using the empirical analysis, the assumption is confirmed that the interaction between the coast to area ratio and the quantity infrastructure in forms of road and rail line density, quality infrastructure in the form of paved roads is insignificant in total factor productivity growth in both fixed and random effects. The results obtained are provided below using random effects, country fixed effects, and linear regression for model fit all with robust standard errors (Table 13). Results for the disaggregated models separately, please refer to the Appendix of this paper (Tables 25, 26, 27, 28, 29)

In this model for the sample for developed countries GDP per capita for the previous period is negatively related to the TFP level for the current period. It is interesting to see that interaction value of coast/area ratio and rail line density shows positive relationship in the TFP level in developed countries where interaction value of coast/area ratio and paved roads proportion shows negative relationship in random effects model. However, at 1%, 5% and 10% significance level, these coefficients are insignificant referring to the inadequate evidence between these factors over the sample period of 1993-2011.

Table 13: Results (2nd Approach, Sample 1 - Advanced Countries)

Variable	Random effects model (Robust Standard Errors)	Fixed effects Model (Robust Standard Errors)	Linear regression (absorbing country) - Robust Standard Errors
lagged gdppc	-.00008***	-.00027***	-.00027***
road density	0.0001	-0.007	-0.007
rail line density	0.021	0.240	0.240
paved roads proportion	-0.008	0.031	0.031
road density*(coast/area)	0.0001	-0.0007	-0.0007
rail density*(coast/area)	-0.001	0.000	0.0008
paved roads*(coast/area)	-0.0001	0.0004	0.0004
coast/area ratio	0.004	(omitted)	(omitted)
dummy	-0.465	(omitted)	(omitted)
_cons	4.329***	7.888	7.888
Observations	373	373	373
R-squared		0.202	0.352
Adjusted R-squared		0.186	0.285

legend: * p<.1; ** p<.05; *** p<.01

2nd approach – Sample 2 (Developing Countries)

Similar to the growth approach, sample of 53 developing countries under the specification of IMF are analyzed in our proposed model (See Descriptive Statistics Table 4 above). Following table presents the aggregated results of the empirical evidence. For separate findings please refer to Appendix (Tables 30, 31, 32, 33, 34)

As it can be seen from the aggregated table below (Table 14), findings of the second approach are somehow mixed and it doesn't show clear evidence of efficiency in the given model. However, it should be stressed that interaction values in the heteroskedasticity robust standard errors prove the paper's original hypothesis. These findings can be interpreted as the negative relationship of TFP level on the given coastal lines. More specifically given the time-invariant coastal lines are negatively correlated to the TFP level such that increase in the transport infrastructure stocks in countries with lengthy coast lines leads to the reduction in the total factor productivity.

Table 14: Results (2nd Approach, Sample 2 - Developing Countries)[1]

Variable	Random effects model (Robust Standard Errors)	Fixed effects model (Robust Standard Errors)	Linear regression (absorbing country) - Robust Standard Errors
lagged gdppc	-.0002***	-.0004***	-.0004***
road density	-0.006	0.001	0.001
rail line density	.609**	0.646	0.646
paved roads proportion	-0.006	-0.019	-0.019
road density*(coast/area)	.000*	**-.001****	-0.001
rail density*(coast/area)	-.029**	**-.055***	-0.055
paved roads*(coast/area)	.002**	0.000	0.000
coast/area ratio	-0.078	(omitted)	(omitted)
dummy	0.167	(omitted)	(omitted)
_cons	2.735*	7.471***	7.471**
Observations	585	585	585
R-squared		0.048	0.265
Adjusted R-squared		-0.056	0.184

legend: * p<.1; ** p<.05; *** p<.01

Unfortunately, these findings contradict the findings of the 1st approach. It is worth mentioning that second model has some statistical errors that are pointed out

[1] Contradicting results comparing to 1st Approach model may be explained by inclusion of some countries as Bangladesh and Philippines in our model. Even though these countries are island or semi-island, intensity of vehicles are very high due to the high population density. Thus, in our fixed effects model, increase in the road or rail line density will diminish the Total Factor Productivity.

above, such as true specification of the model. Considering the difficulty to interpret these findings, robust dynamic panel-data estimation using Arellano-Bond estimates has been carried out to see the lagged value effects (Table 35).

Findings from this model show that the second period of TFP lag denotes the significant relationship, where the first lag is insignificant. Also, significant negative effects of some interaction values in the previous model disappear when the lags of dependent variables introduced in the model. Thus, from the findings of the second approach, paper cannot answer the research question that it has set at the beginning, due to the insufficient evidence.

Summary, Conclusions and Room for Further Research

Summary and Conclusions

The main goal of this paper is to provide the analysis on the efficiency of the transport infrastructure investment and the capital on the productivity of the overall economy from the different angle, particularly considering its geographical location on the access to the waterways. Integrating the length of the shores that countries have into the model under the assumption of to be main driver in both productivity growth and the main determinant of TFP is partially proved to be the main factor in specified models.

The contribution to the productivity growth is analyzed and measured by the transport infrastructure investment and the transport infrastructure stocks. First approach developed in this paper explicitly incorporates the length of the coastal lines of the countries together with transport infrastructure investment that may effect to the total productivity growth. Transport infrastructure investment and coast to area ratio are identified as determinants of the productivity growth and marginal benefit of coastal lines is specifically estimated. However, due to the data deficiency in transport infrastructure investment, public investment used as a proxy in many countries.

Thus, to assure the credibility of the findings the second approach model is developed as a caveat to the given model. The second approach incorporated quantity infrastructure stocks in form of road and rail line density together with coast to area ratio and quality infrastructure indicator in form of the share of paved roads together with coast to area ratio to obtain individual elasticity in overall factor productivity level. Unfortunately, findings of the second approach were not sufficient to approve or to reject the findings of the first approach.

Overall, estimated results can be concluded as quite stable and first model shows significant relationship between the coastal lengths of the country and the overall productivity of the country in developing countries sample, where the findings of second model are mixed. The finding of the first model is matched with numerous papers where they consider them as a means of access. But difference in this paper is that it created the interaction value with transport infrastructure indicators and proved the significant effect of coastal lines on the dependent variable in developing countries. In the meantime, results of the other sample, developed countries, prove the notion that the marginal effect of additional transport infrastructure investment is very small and insignificant in both models.

Quantitative results of this paper can be briefly summarized as follows:

- Dynamic panel-data estimation model shows the magnitude of the interaction value in growth approach (1^{st} approach) to be 0.21 at 5% significant level. This finding can be interpreted as the increase in the transport infrastructure investment in the country with coastal lines can lead to higher economic growth. This finding rejects our null hypothesis on the efficiency of transport infrastructure investment that it benefits inland countries more than coastal country. Thus, having coastal lines positively affects the TFP growth with increase in transport infrastructure investment.

- In the second approach, the results show somehow mixed findings relating to the inadequate evidence to prove or to reject the main hypothesis of this paper. Later in the directions for the future research section the reasons why we could not get enough evidence to approve the null hypothesis will be discussed. This model showed some significant results in the fixed effects model when we retrieve the robust standard errors. However, significant effect is disappeared when the model employed the dynamic effects model. Inclusion of the two lags of the dependent variable, TFP level in this case, all other factors became insignificant in our model.

Room for Future Research

There are number of important issues that require further research, which in this paper author could not improve due to the lack of data together with some difficulties that are faced during the research period.

Data insufficiency. Collection of the data for the transport infrastructure investment for all developing countries in the sample can surely improve the findings of the paper in the growth approach model. Also due to the highly imbalanced data on the road density, rail line density and the paved roads share in the second model, obtaining or collecting the balanced data in a given sample would definitely add its share as well.

Omitted Variables. As the findings of the second model were not able to provide enough evidence to answer the research questions, this consideration of omitted variable would be suitable. As it is mentioned above there are many determinants of the total factor productivity starting from geography to institutions and the behavior, introducing as many possible variables in the model may benefit the main findings. First adjustment could be the introduction of the additional variables including other infrastructure variables other than transport infrastructure in the model, and the other could be consideration of other quality factors as congestion, environmental factors such as noise or smog.

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Appendix

Table 15: Final model regression (1st Approach, Sample 1) - Random Effects

Random-effects GLS regression			Number of obs			569
Group variable: country1			Number of groups			31
R-sq: within = 0.0832			Obs per group: min			13
between = 0.1535			avg			18.4
overall = 0.0847			max			19
			Wald chi2(5)			49.7
corr(u_i, X) = 0 (assumed)			Prob > chi2			0.0000
tfpgrowth	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-6.38	0.000	0.000	0.000
Δinf.investment lagged	-0.815	0.325	-2.51	0.012	-1.451	-0.178
coast/area ratio	-0.002	0.002	-1.12	0.261	-0.006	0.002
inter*	0.003	0.003	1.02	0.309	-0.003	0.010
dummy	-0.348	0.517	-0.67	0.500	-1.361	0.664
_cons	2.045	0.525	3.89	0.000	1.015	3.074
sigma_u	0.901					
sigma_e	2.238					
rho	0.139	(fraction of variance due to u_i)				

*inter=coast/area ratio*Δinf.investment lagged

Table 16: Final model regression (1st Approach, Sample 1) - Random Effects (Robust standard errors)

Fixed-effects (within) regression			Number of obs			569
Group variable: country1			Number of groups	=		31
			Obs per group:			
R-sq: within = 0.0832			min	=		13
between = 0.1535			avg	=		18.4
overall = 0.0847			max	=		19
			F(3,30)			54.39
corr(u_i, Xb) = 0.0000			Prob > F			0.0000
			(Std. Err. adjusted for 31 clusters in country1)			

tfpgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-6.21	0.000	0.000	0.000
Δinf.investment lagged	-0.815	0.480	-1.70	0.089	-1.755	0.126
coast/area ratio	-0.002	0.002	-1.38	0.169	-0.005	0.001
inter*	0.003	0.002	1.50	0.134	-0.001	0.008
dummy	-0.348	0.383	-0.91	0.363	-1.098	0.402
_cons	2.045	0.429	4.77	0.000	1.204	2.885
sigma_u	0.901					
sigma_e	2.238					
rho	0.139	(fraction of variance due to u_i)				

*inter=coast/area ratio*Δinf.investment lagged

Table 17: Final model regression (1st Approach, Sample 1) - Fixed Effects

Fixed-effects (within) regression				Number of obs			569
Group variable: country1				Number of groups			31
R-sq: within = 0.0846				Obs per group: min			13
between = 0.0194				avg			18.4
overall = 0.0034				max			19
				F(4,534)			12.34
corr(u_i, Xb) = -0.9999				Prob > F			0.0000
tfpgrowth	Coef.	Std. Err.	t	P>t	[95% Conf.		Interval]
lagged gdppc	0.000	0.000	-5.93	0.000		0.000	0.000
Δinf.investment lagged	-1.110	0.373	-2.97	0.003		-1.844	-0.377
coast/area ratio	0.630	1.051	0.60	0.549		-1.435	2.695
inter*	0.005	0.004	1.39	0.166		-0.002	0.012
dummy	0.000	(omitted)					
_cons	-30.420	53.580	-0.57	0.570		-135.673	74.833
sigma_u	32845.190						
sigma_e	2.238						
rho	1	(fraction of variance due to u_i)					

*inter=coast/area ratio*Δinf.investment lagged

Table 18: Final model regression (1st Approach, Sample1) - Fixed Effects (Robust Standard Errors)

Fixed-effects (within) regression			Number of obs			569
Group variable: country1			Number of groups			31
R-sq: within = 0.0846			Obs per group: min			13
between = 0.0194			avg			18.4
overall = 0.0034			max			19
			F(3,30)		.	
corr(u_i, Xb) = -0.9999			Prob > F		.	
			(Std. Err. adjusted for 31 clusters in country1)			
tfpgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-5.71	0.000	0.000	0.000
Δinf.investment lagged	-1.110	0.659	-1.69	0.102	-2.455	0.234
coast/area ratio	0.630	0.050	12.73	0.000	0.529	0.731
inter*	0.005	0.003	1.51	0.142	-0.002	0.012
dummy	0.000	(omitted)				
_cons	-30.420	2.155	-14.11	0.000	-34.822	-26.019
sigma_u	91.367					
sigma_e	2.238					
rho	0.999	(fraction of variance due to u_i)				

*inter=coast/area ratio*Δinf.investment lagged

Table 19: Final model regression (1st Approach, Sample 2) - Random Effects

Random-effects GLS regression				Number of obs		1399
Group variable: country1				Number of groups		80
				Obs per group:		
R-sq: within = 0.0376				min		9
between = 0.0924				avg		17.5
overall = 0.0317				max		18
				Wald chi2(5)		44.31
corr(u_i, X) = 0 (assumed)				Prob > chi2		0.0000
tfpgrowth	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-3.31	0.001	0.000	0.000
Δinf.investment lagged	-1.912	0.507	-3.77	0.000	-2.906	-0.918
coast/area ratio	-0.002	0.004	-0.59	0.555	-0.009	0.005
inter*	0.081	0.031	2.64	0.008	0.021	0.141
dummy	-3.192	0.843	-3.78	0.000	-4.845	-1.539
_cons	8.396	1.601	5.24	0.000	5.258	11.534
sigma_u	1.215					
sigma_e	4.533					
rho	0.067	(fraction of variance due to u_i)				

*inter=coast/area ratio*Δinf.investment lagged

Table 20: Final model regression (1st Approach, Sample 2) - Random Effects (Robust Standard Errors)

Fixed-effects (within) regression				Number of obs		1399
Group variable: country1				Number of groups		80
R-sq: within = 0.0376				Obs per group: min		9
between = 0.0924				avg		17.5
overall = 0.0317				max		18
				Wald Chi2(5)		24.41
corr(u_i, Xb) = 0 (assumed)				Prob > chi2		0.0002
(Std. Err. adjusted for 80 clusters in country1)						

tfpgrowth	Coef.	Robust Std. Err.	z	P>z	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-2.53	0.011	0.000	0.000
Δinf.investment lagged	-1.912	0.962	-1.99	0.047	-3.797	-0.027
coast/area ratio	-0.002	0.002	-0.99	0.320	-0.006	0.002
inter*	0.081	0.042	1.93	0.054	-0.001	0.163
dummy	-3.192	1.151	-2.77	0.006	-5.448	-0.936
_cons	8.396	3.033	2.77	0.006	2.451	14.341
sigma_u	1.215					
sigma_e	4.533					
rho	0.067	(fraction of variance due to u_i)				

*inter=coast/area ratio*Δinf.investment lagged

Table 21: Final model regression (1st Approach, Sample 2) - Fixed effects

Fixed-effects (within) regression				Number of obs		1399
Group variable: country1				Number of groups		80
R-sq: within = 0.0423				Obs per group: min		9
between = 0.0162				avg		17.5
overall = 0.0029				max		18
				F(3,1316)		19.38
corr(u_i, Xb) = -0.6586				Prob > F		0.0000
tfpgrowth	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-5.49	0.000	0.000	0.000
Δinf.investment lagged	-2.585	0.544	-4.75	0.000	-3.653	-1.517
car	0.000	(omitted)				
dummy	0.000	(omitted)				
inter*	0.114	0.035	3.23	0.001	0.045	0.183
_cons	8.057	1.445	5.57	0.000	5.222	10.892
sigma_u	2.690					
sigma_e	4.533					
rho	0.260	(fraction of variance due to u_i)				
F test that all u_i=0:		F(79, 1316) = 3.01			Prob > F = 0.0000	

*inter=coast/area ratio*Δinf.investment lagged

Table 22: Final model regression (1st Approach, Sample 2) - Fixed Effects (Robust Standard Errors)

Fixed-effects (within) regression				Number of obs			1399
Group variable: country1				Number of groups			80
R-sq: within = 0.0423				Obs per group: min			9
between = 0.0162				avg			17.5
overall = 0.0029				max			18
				F(**3,79**)			7.3
corr(u_i, Xb) = -0.6586				Prob > chi2			0.0002
				(Std. Err. adjusted for 80 clusters in country1)			
tfpgrowth	Coef.	Robust Std. Err.	z	P>z	[95% Conf.		Interval]
lagged gdppc	0.000	0.000	-3.99	0.000	0.000		0.000
Δinf.investment lagged	-2.585	1.099	-2.35	0.021	-4.772		-0.398
coast/area ratio	0.000	(omitted)					
dummy	0.000	(omitted)					
inter*	0.114	0.049	2.34	0.022	0.017		0.210
_cons	8.057	2.906	2.77	0.007	2.273		13.840
sigma_u	2.690						
sigma_e	4.533						
rho	0.260	(fraction of variance due to u_i)					

*inter=coast/area ratio*Δinf.investment lagged

Table 23: Final model regression (1st Approach, Sample 2) - Linear Model (Absorbing Country – Robust Standard Errors)

Linear regression, absorbing indicators				Number of obs =		1399
				F(3, 1316) =		12.58
				Prob > F =		0.0000
				R-squared =		0.1712
				Adj R-squared =		0.1196
				Root MSE =		4.5333
tfpgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-4.87	0.000	0.000	0.000
Δinf.investment lagged	-2.585	0.754	-3.43	0.001	-4.064	-1.106
car	0.000	(omitted)				
dummy	0.000	(omitted)				
inter*	0.114	0.039	2.91	0.004	0.037	0.190
_cons	8.057	1.984	4.06	0.000	4.165	11.949
country	F(79,1316) =		3.012	0.000	(80 categories)	

*inter=coast/area ratio*Δinf.investment lagged

Table 24: Dynamic Panel - Data Estimation (1st Approach, Sample 2 - Developing Countries)

Arellano-Bond dynamic panel-data estimation		Number of obs	=			1233
Group variable: country1		Number of groups	=			80
Time variable: year						
		Obs per group:	min			6
			avg			15.4125
			max			16
Number of instruments = 156		Wald chi2(6)	=			40.24
		Prob > chi2	=			0
One-step results						
			(Std. Err. adjusted for clustering on country1)			
TFP growth	Coef.	Robust Std. Err.	z	P>z	[95% Conf.	Interval]
TFP growth						
L1.	0.133	0.061	2.19	0.029	0.014	0.253
L2.	0.008	0.033	0.24	0.814	-0.058	0.073
GDP per capita						
L1.	-0.001	0.000	-4.78	0.000	-0.001	0.000
Δinf.investment						
L1.	-3.435	1.315	-2.61	0.009	-6.013	-0.857
coast/area ratio	0.494	0.226	2.18	0.029	0.050	0.938
dummy	0.000	(omitted)				
inter*	0.214	0.096	2.22	0.026	0.025	0.402
_cons	0	(omitted)				
Instruments for differenced equation						
GMM-type: L(2/.).tfpgrowth						
Standard: LD.gdppc LD.linf D.inter						
Instruments for level equation						
Standard: _cons						

*inter=coast/area ratio*Δinf.investment lagged

Table 25: Final model regression (2nd Approach, Sample 1) - Random effects

Random-effects GLS regression				Number of obs		373
Group variable: country1				Number of groups		29
				Obs per group:		
R-sq: within = 0.1498				min		3
between = 0.4838				avg		12.9
overall = 0.1557				max		18
				Wald chi2(9)		50.88
corr(u_i, X) = 0 (assumed)				Prob > chi2		0.0000
TFP	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-5.350	0.000	0.000	0.000
road density	0.000	0.003	0.040	0.965	-0.006	0.007
rail line density	0.022	0.126	0.170	0.863	-0.224	0.268
paved roads proportion	-0.009	0.011	-0.810	0.420	-0.029	0.012
road density*(coast/area)	0.000	0.000	1.410	0.159	0.000	0.000
rail density*(coast/area)	-0.001	0.003	-0.370	0.712	-0.006	0.004
paved roads*(coast/area)	0.000	0.000	-0.930	0.351	-0.001	0.000
coast/area ratio	0.004	0.015	0.300	0.767	-0.024	0.033
dummy	-0.466	0.676	-0.690	0.491	-1.791	0.860
_cons	4.329	1.172	3.700	0.000	2.033	6.626
sigma_u	0.533					
sigma_e	2.205					
rho	0.055	(fraction of variance due to u_i)				

Table 26: Final model regression (2nd Approach, Sample 1) – Random effects (Robust Standard Errors)

Fixed-effects (within) regression				Number of obs			373
Group variable: country1				Number of groups			29
R-sq: within = 0.1498				Obs per group: min			3
between = 0.4838				avg			12.9
overall = 0.1557				max			18
				Wald chi2(9)			134.31
corr(u_i, X) = 0 (assumed)				Prob > chi2			0.0000
				(Std. Err. adjusted for 29 clusters in country1)			
TFP	Coef.	Robust Std. Err.	z	P>z	[95% Conf.		Interval]
lagged gdppc	0.000	0.000	-3.5	0.000	0.000		0.000
road density	0.000	0.003	0.05	0.960	-0.006		0.006
rail line density	0.022	0.134	0.16	0.871	-0.241		0.284
paved roads proportion	-0.009	0.009	-0.93	0.355	-0.027		0.010
road density*(coast/area)	0.000	0.000	1.62	0.105	0.000		0.000
rail density*(coast/area)	-0.001	0.003	-0.31	0.760	-0.008		0.005
paved roads*(coast/area)	0.000	0.000	-1.06	0.290	-0.001		0.000
coast/area ratio	0.004	0.011	0.38	0.704	-0.018		0.027
dummy	-0.466	0.532	-0.88	0.382	-1.509		0.577
_cons	4.329	0.913	4.74	0.000	2.541		6.118
sigma_u	0.533						
sigma_e	2.205						
rho	0.055	(fraction of variance due to u_i)					

Table 27: Final model regression (2nd Approach, Sample 1) - Fixed Effects

Fixed-effects (within) regression				Number of obs			373
Group variable: country1				Number of groups			29
R-sq: within = 0.2020				Obs per group: min			3
between = 0.0418				avg			12.9
overall = 0.0335				max			18
				Wald chi2(10)			12.19
corr(u_i, X) = -0.9388				Prob > chi2			0.0000
TFP	Coef.	Std. Err.	z	P>z	[95% Conf.		Interval]
lagged gdppc	0.000	0.000	-6.84	0.000	0.000		0.000
road density	-0.008	0.026	-0.29	0.769	-0.058		0.043
rail line density	0.241	0.481	0.50	0.617	-0.705		1.186
paved roads proportion	0.032	0.073	0.43	0.664	-0.112		0.176
road density*(coast/area)	-0.001	0.001	-0.84	0.399	-0.002		0.001
rail density*(coast/area)	0.001	0.012	0.07	0.945	-0.022		0.024
paved roads*(coast/area)	0.000	0.001	0.45	0.653	-0.002		0.002
coast/area ratio	0.000	(omitted)					
dummy	0.000	(omitted)					
_cons	7.888	5.986	1.32	0.188	-3.887		19.663
sigma_u	3.989						
sigma_e	2.205						
rho	0.766	(fraction of variance due to u_i)					

F test that all u_i=0: F(28, 337) = 3.62 Prob > F = 0.0000

Table 28: Final model regression (2nd Approach, Sample 1) - Fixed Effects (Robust Standard Error)

Fixed-effects (within) regression				Number of obs			373
Group variable: country1				Number of groups			29
R-sq: within = 0.2020				Obs per group: min			3
between = 0.0418				avg			12.9
overall = 0.0335				max			18
				F(7,28)			16.92
corr(u_i, X) = -0.9388				Prob > F			0.0000
				(Std. Err. adjusted for 29 clusters in country1)			
TFP	Coef.	Robust Std. Err.	z	P>z	[95% Conf.		Interval]
lagged gdppc	0.000	0.000	-5.45	0.000	0.000		0.000
road density	-0.008	0.023	-0.33	0.744	-0.054		0.039
rail line density	0.241	0.451	0.53	0.598	-0.684		1.165
paved roads proportion	0.032	0.104	0.31	0.761	-0.181		0.244
road density*(coast/area)	-0.001	0.001	-0.66	0.517	-0.003		0.002
rail density*(coast/area)	0.001	0.012	0.07	0.945	-0.023		0.025
paved roads*(coast/area)	0.000	0.001	0.34	0.739	-0.002		0.003
coast/area ratio	0.000	(omitted)					
dummy	0.000	(omitted)					
_cons	7.888	6.814	1.16	0.257	-6.071		21.847
sigma_u	3.989						
sigma_e	2.205						
rho	0.766	(fraction of variance due to u_i)					

Table 29: Final model regression (2nd Approach, Sample 1) – Linear Regression (Robust Standard Error)

Linear regression, absorbing indicators				Number of obs =		373
				F(3, 337) =		9.34
				Prob > F =		0.0000
				R-squared =		0.3527
				Adj R-squared =		0.2855
				Root MSE =		2.2055
tfpgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-5.95	0.000	0.000	0.000
road density	-0.008	0.021	-0.36	0.718	-0.048	0.033
rail line density	0.241	0.354	0.68	0.497	-0.456	0.937
paved roads proportion	0.032	0.113	0.28	0.779	-0.191	0.255
road density*(coast/area)	-0.001	0.001	-0.59	0.557	-0.003	0.002
rail density*(coast/area)	0.001	0.012	0.07	0.946	-0.022	0.024
paved roads*(coast/area)	0.000	0.002	0.26	0.793	-0.003	0.004
coast/area ratio	0.000	(omitted)				
dummy	0.000	(omitted)				
_cons	7.888	7.954	0.99	0.322	-7.757	23.533
country	absorbed				(29 categories)	

Table 30: Final model Regression (2nd Approach, Sample 2) - Random Effects

Random-effects GLS regression				Number of obs		585
Group variable: country1				Number of groups		52
R-sq: within = 0.0365				Obs per group: min		1
between = 0.0133				avg		11.2
overall = 0.0128				max		18
				Wald chi2(9)		14
corr(u_i, X) = 0 (assumed)				Prob > chi2		0.1223

TFP level	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-3.53	0.000	0.000	0.000
road density	-0.006	0.015	-0.42	0.678	-0.037	0.024
rail line density	0.610	0.380	1.60	0.109	-0.135	1.355
paved roads proportion	-0.007	0.018	-0.37	0.708	-0.043	0.029
road density*(coast/area)	0.001	0.001	1.05	0.295	-0.001	0.002
rail density*(coast/area)	-0.029	0.020	-1.48	0.138	-0.068	0.009
paved roads*(coast/area)	0.002	0.001	1.61	0.107	0.000	0.005
coast/area ratio	-0.078	0.079	-0.99	0.322	-0.233	0.077
dummy	0.167	1.532	0.11	0.913	-2.836	3.171
_cons	2.736	1.738	1.57	0.116	-0.671	6.143
sigma_u	3.579					
sigma_e	5.187					
rho	0.323	(fraction of variance due to u_i)				

Table 31: Final model regression (2nd Approach, Sample 2) - Random Effects (Robust Standard Errors)

Fixed-effects (within) regression				Number of obs		585
Group variable: country1				Number of groups		52
R-sq: within = 0.0365				Obs per group: min		1
between = 0.0133				avg		11.2
overall = 0.0128				max		18
				Wald chi2(9)		41.82
corr(u_i, X) = 0 (assumed)				Prob > chi2		0.0000
(Std. Err. adjusted for 52 clusters in country1)						

TFP	Coef.	Robust Std. Err.	z	P>z	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-5.33	0.000	0.000	0.000
rd	-0.006	0.009	-0.74	0.461	-0.023	0.011
rl	0.610	0.305	2.00	0.045	0.013	1.207
pav	-0.007	0.011	-0.61	0.542	-0.029	0.015
rdcar	0.001	0.000	1.78	0.076	0.000	0.002
rlcar	-0.029	0.012	-2.43	0.015	-0.053	-0.006
pavcar	0.002	0.001	2.31	0.021	0.000	0.004
car	-0.078	0.048	-1.62	0.106	-0.173	0.017
dummy	0.167	1.469	0.11	0.909	-2.713	3.048
_cons	2.736	1.590	1.72	0.085	-0.380	5.852
sigma_u	3.579					
sigma_e	5.187					
rho	0.323	(fraction of variance due to u_i)				

Table 32: Final model regression (2nd Approach, Sample 2) - Fixed Effects

Fixed-effects (within) regression				Number of obs =			585
Group variable: country1				Number of groups =			52
R-sq: within = 0.0485				Obs per group: min =			1
between = 0.0030				avg =			11.2
overall = 0.0023				max =			18
				F(7,526) =			3.83
corr(u_i, Xb) = -0.9349				Prob > F =			0.0004
TFP level	Coef.	Std. Err.	t	P>t	[95% Conf.		Interval]
lagged gdppc	0.000	0.000	-4.35	0.000	-0.001		0.000
road density	0.001	0.022	0.05	0.962	-0.042		0.044
rail line density	0.647	1.933	0.33	0.738	-3.151		4.444
paved roads proportion	-0.020	0.034	-0.58	0.560	-0.085		0.046
road density*(coast/area)	-0.002	0.002	-0.80	0.425	-0.005		0.002
rail density*(coast/area)	-0.056	0.119	-0.47	0.640	-0.289		0.178
paved roads*(coast/area)	0.001	0.002	0.59	0.554	-0.002		0.004
coast/area ratio	0.000	(omitted)					
dummy	0.000	(omitted)					
_cons	7.471	4.860	1.54	0.125	-2.076		17.018
sigma_u	8.516						
sigma_e	5.187						
rho	0.729	(fraction of variance due to u_i)					
F test that all u_i=0:		F(51,526)	3.5		Prob > F = 0.0000		

Table 33: Final model regression (2nd Approach, Sample 2) - Fixed Effects (Robust Standard Errors)

Fixed-effects (within) regression				Number of obs		585
Group variable: country1				Number of groups		52
R-sq: within = 00485				Obs per group: min		1
between = 0.0030				avg		11.2
overall = 0.0023				max		18
				Wald chi2(10)		126.8
corr(u_i, X) = -0.9349				Prob > chi2		0.0000
(Std. Err. adjusted for 52 clusters in country1)						

TFP	Coef.	Robust Std. Err.	z	P>z	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-5.43	0.000	-0.001	0.000
road density	0.001	0.015	0.07	0.944	-0.029	0.031
rail line density	0.647	0.815	0.79	0.431	-0.990	2.283
paved roads proportion	-0.020	0.012	-1.57	0.122	-0.044	0.005
road density*(coast/area)	-0.002	0.001	-2.19	0.033	-0.003	0.000
rail density*(coast/area)	-0.056	0.032	-1.72	0.091	-0.120	0.009
paved roads*(coast/area)	0.001	0.001	1.36	0.181	0.000	0.002
coast/area ratio	0.000	(omitted)				
dummy	0.000	(omitted)				
_cons	7.471	2.050	3.64	0.001	3.355	11.587
sigma_u	8.516					
sigma_e	5.187					
rho	0.729	(fraction of variance due to u_i)				

Table 34: Final model regression (2nd Approach, Sample 2) - Linear Regression (Absorbing Country - Robust Standard Error)

Linear regression, absorbing indicators						
				Number of obs		585
				F(7, 526)		9.76
				Prob > F		0.0000
				R-squared		0.2655
				Adj R-squared		0.1845
				Root MSE		5.1868

TFP	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagged gdppc	0.000	0.000	-6.01	0.000	-0.001	0.000
road density	0.001	0.020	0.05	0.958	-0.038	0.040
rail line density	0.647	0.806	0.80	0.423	-0.936	2.229
paved roads proportion	-0.020	0.028	-0.70	0.487	-0.075	0.036
road density*(coast/area)	-0.002	0.001	-1.41	0.160	-0.004	0.001
rail density*(coast/area)	-0.056	0.098	-0.57	0.570	-0.248	0.136
paved roads*(coast/area)	0.001	0.001	0.76	0.446	-0.002	0.003
coast/area ratio	0.000	(omitted)				
dummy	0.000	(omitted)				
_cons	7.471	3.248	2.300	0.022	1.091	13.852
country	absorbed				(52 categories)	

Table 35: Dynamic Panel - Data Estimation
(2nd Approach, Sample 2 - Developing Countries)

Arellano-Bond dynamic panel-data estimation				Number of obs	=	454
Group variable: country1				Number of groups	=	48
Time variable: year						
				Obs per group:	min	1
					avg	9.458333
					max	16
Number of instruments = 160				Wald chi2(6)	=	39.85
				Prob > chi2	=	0.0000
One-step results						
(Std. Err. adjusted for clustering on country1)						

TFP	Coef.	Robust Std. Err.	z	P>z	[95% Conf.	Interval]
TFP						
L1.	-0.025	0.038	-0.67	0.505	-0.100	0.049
L2.	-0.070	0.030	-2.31	0.021	-0.129	-0.011
lagged gdppc						
L1.	-0.001	0.000	-3.58	0.000	-0.002	-0.001
road density	0.305	0.208	1.46	0.143	-0.103	0.712
rail line density	2.235	4.158	0.54	0.591	-5.915	10.385
paved roads proportion	-0.022	0.028	-0.80	0.423	-0.076	0.032
road density*(coast/area)	-0.005	0.004	-1.37	0.171	-0.012	0.002
rail density*(coast/area)	-0.099	0.068	-1.44	0.149	-0.233	0.035
paved roads*(coast/area)	0.002	0.003	0.71	0.477	-0.003	0.007
coast/area ratio	0.241	0.930	0.26	0.796	-1.582	2.064
dummy	0	(omitted)				
_cons	0	(omitted)				

Instruments for differenced equation
GMM-type: L(2/.).tfp
Standard: LD.gdppc D.rd D.rl D.pav D.rdcar D.rlcar D.pavcar
Instruments for level equation
Standard: _cons