Transport Infrastructure and Economic Growth
- Determining the effect of investments in transport infrastructure on Gross Domestic Product

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Abstract

Does transport infrastructure have positive and significant correlation with economic growth? To shed some insights on answering this question, this paper examines the effect of transport infrastructure on economic growth by measuring transport infrastructure in two different ways, one as government expenditure in transportation infrastructure and the other one as the actual physical stock of transport infrastructure (as measured by road and railway proxies). Using a panel data of 53 developing countries from 1990 to 2009, the results show that transport infrastructure investment in terms of capitals will lead to average gross domestic product per capita growth rate. The results also indicate that expansion of rail lines that are available for services leads to increase in average gross domestic product per capita growth. The results are, however, inconclusive of paved roads and suggest that more data needs to be collected

1. INTRODUCTION

A country's transportation and transport infrastructure—highways, airports, railroads, and ports—are essential to its economic development. The link between transport infrastructure investment and output growth is important because efficient transport not only enables improvements in inter-regional and international trade, but also increases a country's gross domestic products and its people's welfare. Since transportation is a collective service for the public, it is often provided by the government who in turn incurs the expenses to maintain existing infrastructures and build new ones. However due to the deterioration of the infrastructure within the past few decades has created the demand to maintain or replace the existing infrastructure in most of the countries. For instance, according to a report by the American Society of Civil Engineers (ASCE)[1] in 2009, transport infrastructures in the U.S. have been under-invested towards its actual need and many infrastructures' conditions are deteriorating and even unsafe. Accidents such as the collapse of I-35 Bridge in Minneapolis on August of 2007 show that if this situation is left unattended, similar occurrences will continue to happen and have negative impacts on its economy and international competitiveness in trade. The report by ASCE further suggests that the government should invest more resources on replacing the existing transportation infrastructures that are deteriorating and building new ones in order to keep the transportation system efficient. The estimates from Table 1 (See below in the Appendix) show that investment and maintenance requirements for transport infrastructure are rising. Moreover, as can be seen in Figure 1 (below at the end of this section), most of the developing countries are spending less than 3% of gross domestic product on transport infrastructure in 2003. Furthermore, expanding on the already existing infrastructure is also a

[1] The American Society of Civil Engineers (ASCE) is created in 1852 as a representative body of professional civil engineers. ASCE publishes a large amount of journals, conference proceedings, standards, manuals, and reports each year.

crucial task, especially in developing countries. In Egypt, for example, Loayza and Odawara (2010) shows that transport infrastructure investment will bring positive and significant growth in their gross domestic product, as more modernized transportation can cut down delayed time during transit and manage high level of passengers/traffic better. Thus, it is important to study the relationship between the composition of government expenditure or transport infrastructure and output. In particular, studying the effect of each component (namely defense, health, education, transportation and communication) on growth can provide insights to how government policy can be improved. For instance, Easterly and Rebelo (1993) show that government's expenditure on transportation is positively and significantly correlated with economic growth.

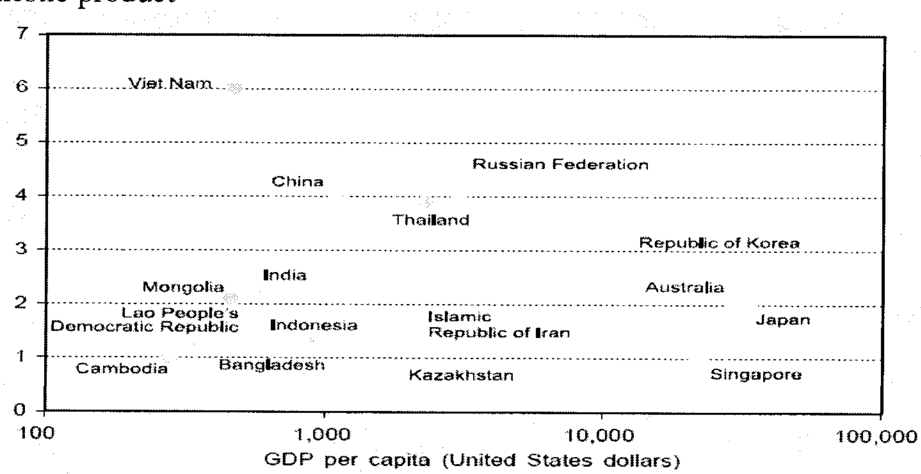
Transport infrastructure not only enables people to meet their daily needs of convenient transportation, but also facilitates a country's economic growth. It is crucial for a country to have efficient transportation system when competing in international trade. Having good quality transport infrastructure is a significant element to promote inter-regional and international trade, as it is able to cut down the time and costs incurred when trading. Transport costs can be very large if the distance of trading between two countries is also great. For example, Brooks, Roland-Holst and Zhai (2005) develop a forecast model for Asian economic growth to 2025 and they find that aggregate growth and real living standards will become higher once conditions for transport and regional trade are improved. Furthermore, the availability of good quality transport infrastructure can attract more net inflows of foreign direct investment for a country. For African economies, Khadaroo and Boopen (2009) find that quantity and quality of physical transport infrastructure that is available plays an important role in persuading foreign investors to choose the countries in their sample as locations for investment. Moreover, Kumar (2005) indicates that when there is sufficient physical stock of transport infrastructure available in a country, this country will attract more net inflows of foreign direct investment because the rate of return will offset the cost of the investment. Efficient development in transport infrastructure may seem costly at first, but it will bring positive effects to foster a country's economic performance and hence promote higher economic growth.

Researchers often encounter various problems when drawing conclusion between the transport infrastructure/government expenditure and economic growth. One frequent drawback is the problem of endogeneity. Endogeneity generally occurs when there is a correlation between the controlled explanatory variables and the error term. It often comes in the form of omitted variable bias, measurement errors, reverse causality, and simultaneity. In such cases, the coefficients obtained from Ordinary Least Squares (OLS) method are biased. In this paper, the problem of reverse causality may occur because it is unclear if the transport expenditure causes economic growth or vice-a-versa. For this paper, computing GDP per capita growth as three-year moving forward averages is expected to help minimize the reverse causality problem. This paper simply lets the data show whether or not the correlation between government spending on transport and average gross domestic product per capita growth rate is significant and positive.

This paper examines the effect of transport infrastructure on economic growth. More importantly, the study distinguishes itself from various other studies by measuring transport infrastructure in two different ways. Model 1 uses investments in transportation infrastructure, while Model 2 utilizes the actual physical stock of transport infrastructure (as measured by road and railway proxies) to verify this effect on average gross domestic product growth rate. Additionally, the models also include certain similar factors such as different components of government expenditure (defence, health, and education), and various time and continental dummies. Unlike many studies that include both developed and developing countries, this paper focuses only on developing countries, assessing whether government spending on transportation outlays would increase average gross domestic product growth that is significant. Finally, using cross-country and time-series analysis, this paper will test the correlation between the share of government outlays for transport infrastructure and economic growth rate in terms of average gross domestic product per capita.

In section 2, some of the literature that examines the effect of transport infrastructure and government expenditure on economic growth is briefly discussed. In Section 3, the source for data and choices of variables are explained in more details. Then in section 4, the above mentioned two models will be described in details. Results for the regression tested in section 4 are discussed in section 5. The results for this paper indicate that in general transport infrastructure has a positive relationship with average gross domestic product per capita growth - except when measuring transport infrastructure using physical stock proxies combined with fixed effects specification. For section 6, the regression from Devarajan et al. (1996) is used to provide a robustness check for the results obtained in section 4. Concluding comments for this paper will be in section 7.

Figure 1: Total investment and maintenance expenditure on transport infrastructure in 2003 as % of gross domestic product



Source: UNESCAP (2006).

2. TRANSPORT INFRASTRUCTURE AND THE EMPIRICAL LITERATURE

This section will briefly review some of the literature that tests the effect of transport infrastructure and government expenditure on economic growth. Most of these studies predict a positive relationship between the transport infrastructure/government expenditure on economic growth.

Most of the empirical literature reviewed relied on cross-country analysis. Due to data availability, total public investment and economic growth are typically measured in terms of aggregate GDP. Since public investment includes several types of expenditures, it is hard to infer the impact of transport infrastructure on economic growth from most of these studies.

Following Aschauer's early works in 1989, the debate over whether infrastructure accumulation promotes economic growth in terms of productivity or income has spurred many interesting arguments. A great number of studies (e.g. Aschauer (1989), Easterly and Rebelo (1993), and Bose and Osborn (2007)) have found empirical evidence supporting that infrastructure has positive effect on aggregate output (i.e. aggregate total factor productivity). Specifically, Gramlich (1994) points out that results from Aschauer (1989) indicates that private investment expenditure can be stimulated as public investment sets to encourage an increase in the rate of return to private capital up to as much as four to seven times in the case of the United States and some other developed countries.

Using a sample of 100 countries from 1970 to 1988, Easterly and Rebelo (1993) observe a consistent and positive correlation between public investment in the transport sector and growth. In particular, their regression shows that a 1% increase in central government investment on transport and communication will lead to a 0.588% to 0.661% increase in per capita growth. They use Instrumental Variable (IV) estimation in order to avoid endogeneity bias and reverse causality. Their choices for instruments are population, per capita income in 1960, the share of agriculture in GDP, and the share of trade share in gross national product. When instrumental variables are taken into account in the case of public investment, that same coefficient increases to 2, meaning a 1% increase in government spending on transport and communication will lead to a 2% increase. They conclude that their results show a significant link between infrastructure and economic growth. However, they point out that more research and data are needed to prove that the link is a causal one from infrastructure to higher output development.

Fedderke and Bogetic (2009) utilize a panel data for the manufacturing industry from 1970 to 2000 in South Africa. Their main objective is to assess whether forms of infrastructure (using 19 different measures) and public capital have any impact on productivity growth[2]. Additionally, their study incorporates the IV estimation techniques to deal with any endogeneity problems. They add two instruments in the regression; the first one is per capita output, and the second is the share of the agricultural and industrial sectors in aggregate South African Gross Domestic Product. They check for the strength of their instruments and find that the instruments are highly correlated with the control variables, but not with the dependent variable. Their results show that transport measures have a negative or insignificant impact on total productivity growth when instrumentation is not included. However, when instruments are added, the same coefficients become positive and significant. For instance, the transport measure for the number of airline passengers was originally found to be negative and insignificant. Nevertheless, when instruments are taken into account, the same coefficient changed to a significant 0.04%, indicating a 1% increase in the infrastructure measure leads to a 0.04% increase in productivity growth. Fedderke and Bogetic (2009) argue that transport infrastructure impacts growth in

[2] Public capita generally refers to public capital stock that is federal, provincial, and local. Transportation system is one major component of public capital and it usually includes highways, railroads, roads, public transit, water supply, and ports...etc (Harchaoui and Tarkhani 2003).

manufacturing sector when potential endogeneity is controlled.

Devarajan, Swaroop, and Zou (1996) examine the relationship between the composition of government expenditure and economic growth. They use annual data on 43 developing countries and 21 developed countries from the period of 1970 to 1990 provided by Government Financial Statistics (GFS), annual reports published by the International Monetary Funds (IMF), to investigate this relation. Their study include two separate data samples, the first one concentrates on only developing countries and the second one focuses on developed countries. In their first sample which only includes developing countries, their results suggest that capital expenditure (i.e. infrastructure) and growth are positively correlated, while current expenditures are negatively correlated with growth. Further, their estimated coefficients on transport and communication are found to be statistically significant and negative. However, these conclusions are reversed once the second sample of 21 developed countries is used instead. Nevertheless, their empirical analysis shows that a positive relationship exists between government spending and GDP growth.

Isaksson (2009) examines the impact of roads and railways on the manufacturing sector for over 80 advanced and developing countries. The data on transport infrastructure come from Canning (1998)[3], which is one of the more complete databases for roads and railways. Isaksson (2009) shows that transport infrastructure does explain why some countries have managed to develop economically while others have not between 1970 and 2000. In particular, his regression indicates that a 10% increase of railway infrastructure will lead to a 4% expansion of manufacturing per capita. Additionally, in the case of road infrastructure (i.e. paved roads), his

[3] Canning (1998) has created a database specifically for world infrastructure stocks from 1950 to 1995. The database includes 152 countries and is complied of annual data on six infrastructure measures: (1) kilometres of roads; (2) paved roads; (3) kilometres of railway lines; (4) number of telephones; (5) number of telephone main lines; (6) kilowatts of electricity generating capacity.

results validate the hypothesis that expanding transport infrastructure impacts the economy differently at different stages of the development, especially for the lowest income countries and the Asian meta-countries.[4] Specifically, for the Asian meta-countries, a faster growth rate for both road and railway infrastructure investment triggers economical development, indicating that more resources should be invested on roads and railways. Overall, Isaksson (2009)'s work emphasizes the significance of transport infrastructure as an explanatory variable for long-term economic development.

In a time-series study on Mexico, Noriega and Fontenla (2005) develop a model to better investigate not only the long-run impact of public infrastructure on output, but also the optimality with which levels of infrastructure have been set from 1950 to 1994. They use the method of long-run derivatives[5] on three economic infrastructure measures: kilowatts of electricity, kilometres of roads, and number of telephone lines. In particular, kilometres of roads are used to measure the physical stocks of transportation infrastructure. They find that all three infrastructure measures have positive and significant effects on real gross domestic product. Specifically, for roads, the shock from public investment becomes significant after 8 years. Their results confirm the growth model theory that endogenous factors of production are the main source for long-run economic growth.[6] So accumulation of transport infrastructure will lead to higher output. Another recent work on Mexican case is Ramirez (2004). Differing from the study

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[4] Meta-countries refer to the Asian countries whose economies are vastly developing and they are often called Asian Tigers. Countries that are included in the Tigers are: China, India, Indonesia, republic of Korea, Malaysia, Singapore, and Thailand.

[5] Long-run derivatives is a method developed by Fisher and Seater (1993) to measure the effects money has on output in the long run for Mexico. In a bivariate ARIMA model, they demonstrate the concept difference between long-run neutrality and long-run superneutrality. In simple terms, long-run derivative = limit of long run elasticity of output with respect to money.

[6] According to Neoclassical growth models, increasing inputs in terms of capitals and human capitals will lead to increase in output. However, decreasing return to scale exists when not all the inputs are increased at the same time. For example, if only capitals are increased while human capitals are not, the increase to output will get smaller as capitals gets bigger (Mare, 2004).

by Noriega and Fontenla (2005), Ramirez uses aggregate data and a vector error correction approach instead to assess the impacts of public infrastructure on Mexico's economic growth. Nonetheless, Ramirez (2004) also comes to the similar conclusion as Noriega and Fontenla (2005), in which public investment in transport has a positive significant effect on real GDP.

In addition to previously mentioned studies, Loayza and Odawara (2010) did an extensive study on how the provision of infrastructure has impacted Egypt's gross domestic product per capita growth rate when comparing with 77 other countries in the sample from 1961 to 2005. His regression shows that the coefficient for transportation index is estimated to be positive and significant. The coefficient implies that a 1% improvement in transportation in terms of increased share of paved roads in the overall road network leads to a 1.24% to 2.05% increase in gross domestic product per capita growth rate. His results demonstrate that transport infrastructure is an important factor contributing to Egypt's income level. Furthermore, several scenarios are included in their study to predict the impact of different level of increased investment in infrastructure. The results for these projections indicate that higher infrastructure investment will be very beneficial to Egypt if efficient public expenditure reform and private-sector co-participation are taken into account to offset government burden.

A more recent study on India's railroad network by Donaldson (2010) re-affirms the prediction in transport infrastructure literature of a positive relationship between the transport infrastructure/government expenditure on economic growth from 1870 to 1930. Focusing his work on India's extensive railroads network built in India's colonial period, he reconstructs a new data sample from the archival records on India's economic activity relating to railroads. His findings indicate that the use of railroads can improve trade volumes because the cost of transportation can be cut down, the merchandise price gap between different regions that are connected by the railroads can be minimized, and hence, inter-regional trading is encouraged. Furthermore, his regression shows that by having railroads in the region, real agricultural income for that region can be increased by 16.40%, implying that railroad network increases economic development significantly in terms of real agricultural income and welfare. Donaldson (2010)'s work demonstrates railroad network has acted as an important transport infrastructure in improving the trading environment in India.

The studies reviewed in this section have all validated the significance of transport infrastructure and government expenditure on the economic growth. In section 3, this empirical paper will provide empirical analysis to test this hypothesis using data on 53 developing countries from 1990 to 2005.

3. DATA

Annual data on 53 developing countries (see the list in the Appendix A) from 1990 through 2009 are used to assess the relationship between composition of government spending, average gross domestic product per capita growth rate and transport infrastructure measures. This panel database consists of two different sources. For the data on government expenditure, the primary source is the central government budgetary account in Government Finance Statistics (GFS), which is published annually by the International Monetary Fund (IMF). The central government budgetary account is chosen mainly because central government is typically the one authority that is responsible for providing collective public services, such as national defence, education, health care, transportation etc. Variables included in the government expenditure are total central government outlays, expenditure for defense, education, health, communication and transport. The expenditure variable on communication and transport is used as a proxy for expenditure in transport infrastructure for the regression analysis. Data on gross domestic product, the dependent variable, is drawn from World Development Indicators in terms of gross domestic product per capita growth annual percentage. The World Development Indicators are provided by the World Bank database.

The two models in Section 4 are modified after the work of Devarajan et al. (1996). Different components of government spending are included into the regression as explanatory variables and they are measured as share of each component—mainly defense, health, education, communication and transport—in total government spending. According to the Government Finance Statistics Manual, there are two ways to classify expenditures: one is depending on expenditure's function and the other on economic characteristics of the expenditure. The measure for defense, health, education, and transport variables follow IMF's definition for expenditure share by functional classification, while current and capital expenditure follow the economic classification. Capital expenditure covers data on government's spending on new or existing capital goods, and the use of goods and services. On the other hand, Current expenditure includes compensation of employees, interest payments, subsidies, grants, social benefits, and other expenses. Data on shares associated with transport and communication expenditure measure mainly spending on transport because most of the data on communication spending is either missing or small in value. Thus, the variable (TAC/TE) will be a good proxy indicator for transport expenditure.

Measure for the share of government spending in gross domestic product is included to control for effects of financing government spending on growth. A continental dummy is added to control for the continent-specific effect since the pattern for economic growth is often different for each continent. Six continental dummies are created to categorize the 53 countries in the sample. The six categories are: Asia, Africa, Europe, North America, Oceania, and South America. Furthermore, the foreign direct investment (FDI) net inflow as percentage of gross domestic product is included as one of the control variables to account for the external shocks that can impact a country's growth rate. Foreign direct investment is included as one factor that is associated with economic growth but do not necessarily has a direct relationship with the determined shares of government expenditure. This is based on various studies such as Borensztein, Gregorio and Lee (1998)[7] where FDI has been found to be a significant factor contributing to economic growth, especially for developing countries. When net inflows of foreign direct investment are high in a country, this means that there are more foreign countries or companies interested in investing in this country since according to World Development Indicator, net inflows of foreign direct investment are measured if the investment has lasted a minimum of six months. This further implies that the economic climate is attractive in that country and there is no bad domestic disturbance/shock, or otherwise foreign investors will not be willing to put their resources into that country. Thus, higher net inflows of foreign direct investment suggest that there is a more balanced economy in a country, and hence economic growth is encouraged as high rate of foreign direct investment often represents foreign investors' confidence in that country. Moreover, Jensen (2003) indicates that countries with a democratic political system attract more FDI than their authoritarian counterparts.

The physical stocks of proxies that are used to measure the transport infrastructure are paved roads as percentage of total toads and rail lines (total routes in kilometres). Both of these measures are provided by the World Development Indicators. In model 1, the different

[7] They find that by promoting technological development, FDI will be an important factor that contributes more than domestic investment to improve economic growth, particularly in developing countries.

components of government expenditure are used to measure how much capital is actually invested on transport infrastructure. As for model 2, total roads and rail lines are transport indicators that measure the physical quantities on how much infrastructure is created with all those resources.

Finally, the dependent variable is collected from the World Development Indicators and is computed based on annual percentage growth rate of gross domestic product per capita on local currency. Furthermore, gross domestic product per capita growth annual percentage is calculated as three- year moving forward average in order to exclude short-term fluctuation in this empirical paper. For instance, for year 1990, the three-year moving forward average will be computed as the following:

$$\text{GDP per capita growth}_{1990} = \text{GDP per capita growth of } (1990+1991+1992)/3$$

Generally, it takes time to determine whether the government's expenditure on public investment would have any real effects on economic growth. This paper chooses three-year average instead of other longer year average due to data limitation. Moreover, another reason for using the three-year moving average for gross domestic product per capita is to minimize the presence of reverse causality. The three-year average sets the restriction on government's expectation of its future conditions up to three years. For instance, government has to anticipate what is going to happen to growth rate up to three years in the future and increase/decrease expenditure today.

Table 2 and 3 provide the descriptive statistics for model 1 and 2, respectively.[8] From Table 2, ratio of current expenditure to total government outlays is reported to be 0.24% on average, indicating that 24% of the government expenditure goes to current expenditure. Similarly, the data suggests that on an average capita, defense, and education account for 6%, 4%, and 5% of government spending budget, respectively. For health and transportation,

[8] The Tables are provided in Appendix at the end of the paper.

government expenditure is reported to around 2% for both categories. The total government expenditure is measured to account for 13.10% of gross domestic product. For foreign direct investment, it accounts for 2.89% of gross domestic product on average for each country.

Table 3 presents the descriptive statistics for model 2, which includes all the variables from model 1 and two additional variables — paved roads and rail lines. Ratio of current expenditure, capital expenditure, defense, health, and education are still similar to the ones reported in Table 2. Total government expenditures that are accounted for gross domestic product is still around 13%, while foreign direct investment is around 2.39% of gross domestic product on average in model 2. Total length of rail lines that are operating are reported to be 8711.41 kilometres on average. For paved roads, total length available on average is 50.10 kilometres.

4. MODEL

Model 1

As in Devarajan et al. (1996), model 1 examines the relationship between various government expenditures and average gross domestic product per capita annual percentage growth, taking each government's budget decision as given. One difference is that foreign direct investment is included as the one variable controlling for external shocks of each country, whereas Devarajan et al. (1996) use instead black market premium and a calculated shock variable (computed using export/import indices) Model 1 focuses on determining whether government spending on transport infrastructure will impact output significantly. This is estimated using:

$$\text{Average Growth Rate}^i = \beta_1 (TE/GDP)^i + \beta_2 (Def/TE)^i + + \beta_3 (Hlth/TE)^i$$
$$+ \beta_4 (Ed/TE)^I + \beta_5 (Tac/TE)^i + \beta_6 (TE/GDP)^i$$
$$+ \beta_7 (Cur/TE)^i + \beta_8 (Cap/TE)^i + \beta_9 (FDI)^i + \sum^5_{j=1}\beta_j D_j$$
$$+ \sum^{15}_{k=1}\beta_k Year_k + \varepsilon_i$$

The variables are:

Average Growth Rate^i: Annual percentage of gross domestic product per capita computed in three-year moving average for country i.

$(TE/GDP)^i$: Share of total government outlays in gross domestic product for country i.

$(Def/TE)^i$, $(Hlth/TE)^i$, $(Ed/TE)^i$, and $(Tac/TE)^i$: All five variables are ratios of government spending to total government outlays for country i. The four indicators here refer to expenditure on defense, health, education, transport and communication.

$(Cur/TE)^i$: Ratio of current or recurrent expenditure, which includes wages and salaries, other goods and services, interest payments, and subsidies, to total government outlays for country i.

$(Cap/TE)^i$: ratio of capital expenditure, which covers payments for new/existing durable goods, to total government outlays for country i.

$(FDI)^i$: Net inflows of foreign direct investment as percentage of gross domestic product for country i.

$\sum^5_{j=1}\beta_j D_j$: Continental dummy variables; j = 1, 2, 3, 4, 5, and 6 correspond to Asia, Africa, Europe, North America, Oceania, and South America.

$\sum^{15}_{k=1}\beta_k Year_k$: Year dummy variables; j = 6 - 20 correspond to year starting from 1990- 2004, respectively.

Model 2

This main difference of this model with respect to model 1 is that the share of transport expenditure in total government expenditure is replaced with physical transport indicators of paved roads and rail lines. The model is now modified to measure the effect physical transport infrastructures have on average gross domestic product per capita growth rate. This is estimated as the following:

$$\text{Average Growth Rate}^i = \beta_1 (TE/GDP)^i + \beta_2 (Def/TE)^i + \beta_3 (Hlth/TE)^i + \beta_4 (Ed/TE)^I + \beta_5 (Cur/TE)^i + \beta_6 (Cap/TE)^i + \beta_7 (FDI)^i + \beta_8 (road)^i + \beta_9 (rail)^i + \sum^5_{j=1}\beta_j D_j + \sum^{15}_{k=1}\beta_k Year_k + \varepsilon_i$$

where

$(road)^i$: paved roads as percentage of total roads available in country i.

$(rail)^i$: the length of rail routes operating and providing services in country i.

The variables are almost all the same as the ones in model 1, except the variables for road and rail, which are the transport indicators measuring the physical stocks of paved roads as percentage of total roads and the total length of rail routes available for train services, respectively. The variable for ratio of transport expenditure to total government expenditure, namely $(Tac/TE)^i$, is not included in model 2. If this variable is included in the regression, the problem of multicollinearity will exist since the newly added physical transport indicators also measure transport infrastructure.

5. RESULTS

The purpose of both models is to investigate whether transport infrastructure has impacts on economic growth. In particular, transport infrastructure is measured using two different indicators, in order to determine if both measures are correlated with average GDP growth rate. The empirical results discussed in this section use two methods: first with ordinary least squares (OLS) method, second with fixed-effect. Nevertheless, results from fixed-effect method are more consistent because existence of unobserved individual heterogeneity between developing countries is already assumed in the model. Table 4 provides the empirical results for model 1, while results for model 2 can be found in Table 5.

From model 1

Model 1's objective is to examine the relationship between different components of government expenditure and output growth. In particular, as discussed in previous sections, the correlation between public investment for transport infrastructure investment and average gross domestic product per capita growth rate is tested. The main regression results (see Table 4) show that the relationship between three-year moving average and transport expenditure (TAC/TE) is positive and statistically significant at 95% confidence interval for both OLS estimation and fixed-effect model. From the fixed-effect model, a 1% increase in the ratio of transportation to total expenditure leads to a very large increase of 20.60% in average growth rate of gross domestic product per capita. Moreover, since ratio of transport expenditure to total government expenditure is reported to be 2% on average, an increase of 1% corresponds to increase in 50% of the transport expenditure. This means that an increase of 50% in transport expenditure will increase the average gross domestic product growth rate by 20.60%. This result implies that transportation investment from the government is positively correlated with average growth rate. The result is, however, not conclusive on whether the relationship is a causal one in this paper. Nevertheless, the result provided in this section demonstrates that the association between transport expenditure and average gross domestic product per-capita growth is strongly positive, and hence suggesting that investment in transport infrastructure is important to foster economic growth. The result in this paper is consistent with the findings of reviewed literature discussed in section 2, in which a consistent and positive correlation is predicted to exist between public investment in the transport sector and growth.

Following ideas provided in Devarajan et al. (1996), total expenses of government outlays is computed as percentage of gross domestic product to keep all the other expenditures level in the regression. For instance, this means that if government spends more on education, then it would have to spend less on other expenditures such as defense or health so the overall expenditures can maintain the government's budget. Table 4 presents the results for model 1 regression and shows that this variable has a positive correlation with average growth rate in both OLS estimation and fixed-effect. Both results from OLS and fixed-effect methods indicate that this variable is statistically significant at 95% confidence interval.

Ratio of current expenditure (net of interest payments) to total expenditure is also shown to have a positive effect on average gross domestic product per capita growth for both OLS and fixed-effect models. Both methods suggest current investment to be significant at 1% level. The coefficient estimated for this ratio is reported to be 3.42, indicating a 1% increase in current government expenditure brings up the average gross domestic growth rate by 3.42% for the fixed-effect model. On average the ratio of current expenditure to total government expenditure is reported as 24%, which means an increase of 1% corresponds to increasing in 4.17% of the current expenditure. It is this increase of 4.17% that leads to an increase in average gross domestic product per capita growth of 3.42%. On the other hand, ratio of capital expenditure to total expenditure is also estimated to have a significant relationship with average growth rate for both OLS and fixed-effect models. However, the relationship is reported to be a negative one with coefficient estimated as -8.40 in the fixed-effect method. Specifically, this coefficient shows that by increasing spending on capital investment, it will lead to 8.40% decrease in average gross domestic product growth. As ratio of capital expenditure to total government expenditure is reported to be 6% on average, an increase of 1 % corresponds to increasing in 16.67% of the capital expenditure. It is this increase of 16.67% that leads to a decrease in average gross domestic product per capita growth of 8.40%. This result is interesting as it contradicts with developing countries' objective towards public policy, in which capital rather than current expenditure is used to encourage economic development. When government increases spending on capital goods, such as roads, railroads, ports, and airports etc, it is normal to assume such expenditures have positive impact on economic growth. The results here are similar to what Devarajan et al. (1996) have found in their model with regards to capital expenditure and current expenditure. They suggest that these results arise because developing countries with low growth rates may be investing more resources on capital expenditures, such as schools or hospitals, in order to catch up with the rest of the world. These results are puzzling and future studies can investigate more about this matter.

The results for defense and education expenditure are both significant at the 5% critical value for both OLS and fixed effect models. From the fixed-effect method, the estimated coefficient of 14.80 suggests that defense spending has a positive impact on average gross domestic product growth rate. However, the result shows that with education spending, the effect is negative. When there is a 1% increase in government investing in defense, average gross domestic product per capita growth rate will increase by 14.80%. In particular, since ratio of defense expenditure to total government expenditure is reported to be 4% on average, an increase of 1 % corresponds to increasing in 25% of the defense expenditure. It is this increase of 25% that leads to an increase in average gross domestic product growth of 14.80%. One possible explanation for defense expenditure having a positive sign towards average gross domestic product growth rate is that defense expenditures are counted as capital goods and accumulating capital goods should increase economic growth. As for the education expenditure, the negative sign of its coefficient can be explained as what Devarajan et al. (1996) have suggested in their study that developing countries with low growth rate may invest more on education to encourage economic development and the expenses incurred to improve education may become very big for the government since supplementary services to education can be very costly (e.g. food, medical, transportation and other services to students). Result of fixed-effect method presented in Table 4 implies that a 1% increase in education expenditure leads to a 9.60% decrease in average gross domestic product per capita growth. Ratio of education expenditure to total government expenditure is reported as 5% on average, so an increase of 1% corresponds to increasing in 20% of the education expenditure. It is this increase of 20% that leads to a decrease in average gross domestic product per capita growth of 9.60%. Nonetheless, according to Neo-classical growth theory, by investing more in education, a country can increase its accumulation of overall human capital and skilled labour, and hence enabling its economy to perform more efficient (Mare, 2004). The results for education expenditure are puzzling and further studies can focus on that subject more.

Ratio of health expenditure to total expenditure (Hlth/TE) is shown to be positively related to average per-capita growth rate for both OLS and fixed-effect methods. The result is, however, not significant in both methods. One suggesting explanation could be that developing countries are allocating more resources to be spent on other expenditures - such as education. However, future studies can focus on different categories of expenditures in health spending and see if any correlation exists between health expenditures and gross domestic product growth.

The variable for net inflows of foreign direct investment as percentage of gross domestic product is also estimated to be positive and insignificant for both OLS and fixed-effect methods. The sign for this variable is as expected. Although the result shows foreign direct investment variable to be insignificant, it is possible that this variable will have more contributing effects on average gross domestic product growth rate if more data can be included for future studies. Borensztein et al (1998) suggest that foreign direct investment will contribute more to per-capita growth when the hosting countries have reached a sufficient level of absorptive capability, especially for developing countries. The contribution from foreign direct investment is not being picked up yet, as more data is needed for further investigation on the relationship between foreign direct investment and gross domestic product per capita growth.

From Model 2

Results from model 2 can be found in Table 5. The proxies for transport infrastructure provide some interesting results. The results for the total length of rail lines available for service and paved roads are both found to be statistically insignificant. It is possible that the data on paved roads is not very reliable for some countries. For future studies, it would be helpful if more complete data over the years can be collected for developing countries, since lack of quality data is one problem researchers always encounter when examining developing countries.

Ratio of current expenditure to total government expenditure is found to be statistically significant at 1% level. In particular, this ratio is reported as 25% on average, so an increase of 1% corresponds to increasing in 4% of the current expenditure. It is this increase of 4% that leads to an increase in average gross domestic product per capita growth of 5.68%. The coefficients of the factors such as defense investment and health spending are not statistically significant. With regards to variables of capital expenditure, no statistically significant results are also found. Education expenditure however, is found to have a negative significant relationship with average growth rate at 1% level. A 1% increase in education expenditure will lead to 17.6% decrease on average gross domestic product growth. The variable used to control for the level effects in the regression is measure by the total government expenditure as percentage of gross domestic product, and this variable is still significant at critical value of 1% level. The results also show that the coefficient for net inflows of foreign direct investment as percentage of gross domestic product is statistically insignificant for either OLS or fixed-effect methods, even though its coefficient is positive. The sign for this variable is still the same as what have been expected. Foreign direct investment is beneficial to improve a country's economic development, especially when a country has accumulated enough human capital. According to Borensztein el (1998), this is because when human capital reaches a sufficient level, the country's absorptive capability will be efficient enough to enable foreign direct investment to contribute more towards technological progression.

6. ROBUSTNESS CHECK

In this section, a robustness check is performed to verify if the results from model 1 in section 4 hold after controlling for black market premium and other domestic policy shock. Given that the models in this paper is modified after the works of Devarajan et al. (1996), in this section, a simulation of their model will be used to regress with the data provided in this paper. By running the same regression with a different sample of 42 developing countries, this will show the readers if there are consistent/inconsistent findings when comparing the analysis of this paper and of Devarajan et al. (1996). The regression being compared with the model 1 in section 4 is:

$$\text{Average Growth Rate}^{i} = \beta_1\,(TE/GDP)^{i} + \beta_2\,(Def/TE)^{i} + + \beta_3\,(Hlth/TE)^{i}$$
$$+ \beta_4\,(Ed/TE)^{I} + \beta_5\,(Tac/TE)^{i} + \beta_6\,(TE/GDP)^{i}$$
$$+ \beta_7\,(Cur/TE)^{i} + \beta_8\,(Cap/TE)^{i} + \beta_9\,(BMP)^{i}$$
$$+ \beta_{10}\,(SHOCK)^{i} + \sum^{5}_{j=1}\beta_j D_j + \beta_k\,(Year)^{i}_{t} + \varepsilon_i$$

Black market premium and the Shock variable are included into the regression. Global Development Network Growth Database provides the data on black market premium. This database is developed by Easterly (2001) about variables of macro/micro time series, government finance, social indicators and fixed factors. In the database, black market premium is calculated following the formula:

$$BMP_t = (\text{parallel } X_{rate}/\text{official } X_{rate-1})*100.$$

However, the data on this variable cuts down the year for data to include only six years: 1990, 1991, 1992, 1993, 1996, and 1997. The reason for this limiting data to include only these years is that there is many missing data on the other years. Moreover, this also cuts down the number of developing countries included in the sample from 53 to 42.

The Shock variable is computed as a weighted average of changes in the world real interest rate (R) and the export price index (PX) and import price index (PM) in accordance to the formula provided by Devarajan et al. (1996):

$$SHOCK_t = (R_{t+1,\,t+5} - R_{t-4,\,t})*(Debt/GDP)_t - (PX_{t+1,\,t+5} - PX_{t-4,\,t})*(Exports/GDP)_t$$

$$+ (PM_{t+1,\,t+5} - PM_{t-4,\,t})*(Imports/GDP)_t$$

where $(Debt/GDP)_t$, $(Exports/GDP)_t$ and $(Imports/GDP)_t$ measure the ratios of central government debts, exports, and imports to GDP, respectively. World Development Indicator provides the data on total central government debt as percentage of gross domestic product. For the data on export and import price indices, this paper decides to use the data on export/import value indices instead. The reason for this is that according to the World Bank Statistical Manual, not all the countries in the sample here collect information on export/import price indices. Although the unit value indices will generally overstate prices changes, it will still capture the effect of shocks consistently as long as all the countries use the same indices.

Table 6 provides the descriptive statistics for the model used in this section for robustness check. Ratio of current expenditure to total government outlays is reported to be 0.30 on average, indicating that 30% of the government budget goes to current expenditure. As for capital expenditure, defense, and health, the ratio is reported to account for 7%, 5% and 2% of government budget, respectively. Education and transportation are reported to account for 6% and 2% of total government expenditure. Total government outlays are reported to be around 9% on average of gross domestic product. Net inflows of foreign direct investment can account for 1.85% of gross domestic product. On an average, black market premium is found to be 28.13% for all the countries over the time period.

Table 7 provides the results of the regression, when variables of (BMP) and (SHOCK) are used in the model, while foreign direct investment variable is not used. The results obtained are very similar to Devarajan et al. (1996). With regards to transport expenditure, Devarajan et al. (1996) find that it is found to be insignificant, though the coefficient for transport expenditure is reported to be negative. The results in Table 7 also indicate that no statistically significant correlation is found between transport infrastructure and average growth rate. The countries and years included in Devarajan et al. (1996) and this paper are similar but more countries and updated years are included in this paper. Devarajan et al. (1996) test their model with a data sample of 43 countries from 1970 to 1990, while the data examined here uses more recent data of 53 countries from 1990 to 2005.[9] Moreover, it is possible that the countries studied by Devarajan et al. (1996) and this paper are slow in growing and they were spending more to invest on transport expenditure in order to foster their economy during 1970 to 1990. This would explain why no significant relationship is found by Devarajan et al. (1996) and this paper.

Furthermore, black market premium is found to be statistically insignificant since the p-value is estimated to be 0.472 from the fixed-effect method. The coefficient for this variable is found to be negative and it is expected that black market premium will have a negative effect on average output growth if any, because markets generally perform badly when black market premium is high enough to distort the economy. On the other hand, the result shows that shock variable is statistically significant and positive. From the fixed-effect method, a 1% increase in shock leads to 0.0010% increase in average growth.

Thus, the results suggest that even after controlling for black market premium and external shocks, no statistically significant relationship is found between transport and average growth rate.

[9] See Appendix for the list of countries included in this paper.

7. CONCLUSIONS

In this paper, the effect that different components of government expenditure, specifically spending on transportation, have on the average growth rate of gross domestic product per capita for developing countries is assessed. Previous literature generally predicts that the relationship between transport infrastructure investment and economic growth in terms of gross domestic product per capita will be significant and positive. The results presented in section 5 with regards to model 1 and 2 show mixed results. Model 1 results from Table 4 indicate that there is statistically significant positive correlation between transport infrastructure investments and economic growth. Specifically, a 50% increase in the current expenditures in transportation leads to an increase of 20.60% in average growth rate of gross domestic product per capita. On the other hand, model 2 results show that no statistically significant results are found between physical stocks of transport infrastructure and average growth rate. The possible reason why model 2 finds no significant result between the two variables is mainly due to lack of good quality data. For future studies, more data can be collected to investigate more on this subject. By measuring transport infrastructure investment in terms of both monetary expenditure and physical quantity of stocks, model 1 and 2 provide puzzling results with regard to whether transport infrastructure affects gross domestic product. More data needed to be collected so further studies can investigate more on this matter. It is possible that many developing countries do not have the clear definition or guidelines on how to measure their physical infrastructure such as paved roads. Moreover, it is also possible that smaller developing countries would usually have just one type of transportation. Future studies can also include different modes of transport infrastructure.

For future researches, similar studies with the one done in this paper can provide more insights into the effects transport infrastructure investment has on developing countries' economic growth if more years and detailed data are available. It is often difficult to collect information about the variables examined in this paper for developing countries. Future studies can also focus on including more variables that are relevant to make the analysis more complete. Moreover, the question regarding whether there are other reasons to affect the government's objective in determining its expenditure can also be an interesting topic for further research.

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APPENDIX

There are 53 countries included in the data and they are as the following: Albania, Algeria, Argentina, Bangladesh, Belarus, Belize, Bolivia, Brazil, Bulgaria, Cameroon, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Dominican Republic, Egypt, El Salvador, Ethiopia, Ghana, Greece, Guatemala, Hungary, India, Indonesia, Kenya, Korea, Mauritius, Mexico, Morocco, Nicaragua, Pakistan, Panama, Paraguay, Philippines, Poland, Romania, Russian Federation, Singapore, Slovenia, South Africa, Sri Lanka, Sudan, Thailand, Turkey, Uganda, Ukraine, Uruguay, Vanuatu, Rep. Bol. of Venezuela, Republic of Yemen, Zambia

Continental Dummy (D1, D2, D3, D4, D5; base continent is D6)
1 = Asia: Bangladesh, China, India, Indonesia, Korea, Pakistan, Philippines, Russian Federation, Singapore, Sri Lanka, Thailand, Turkey, Republic of Yemen,

2 = Africa: Algeria, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Mauritius, Morocco, South Africa, Sudan, Uganda, Zambia

3 = Europe: Albania, Belarus, Bulgaria, Croatia, Cyprus, Czech Republic, Greece, Hungary, Poland, Romania, Slovenia, Ukraine,

4 = North America: Belize, Costa Rica, Dominican Republic, El Salvador, Guatemala, Mexico, Nicaragua, Panama,

5 = Oceania: Vanuatu

6 = South America: Argentina, Bolivia, Brazil, Colombia, Paraguay, Uruguay, Rep. Bol. of Venezuela

Table 1: Estimates of average annual investment and maintenance requirements in the transport sector from 2005 to 2015

		North and Central Asia	South and South-West Asia	South-East Asia	East and North-East Asia	Australia, New Zealand and the Pacific	ESCAP region Total	Developing Asia-Pacific countries
Total	1990-1995	17.0	48.2	15.8	39.9	16.6	137	107
	1995-2000	12.9	49.9	12.1	50.6	11.4	137	112
	2000-2005	18.8	61.8	19.7	88.4	16.2	205	172
	2005-2010	19.7	71.4	22.8	101.1	15.8	231	195
	2010-2015	22.9	86.2	27.4	138.0	18.0	292	253
Roads	1990-1995	13.7	45.6	13.4	33.2	14.7	121	95
	1995-2000	10.0	47.0	10.6	43.5	9.9	121	100
	2000-2005	14.4	57.5	14.2	70.5	13.1	170	145
	2005-2010	14.5	64.8	14.7	78.3	12.2	185	161
	2010-2015	17.5	76.3	17.2	106.7	13.5	231	206
Railways	1990-1995	2.8	1.8	0.5	1.9	0.8	7.8	6.7
	1995-2000	2.6	1.9	0.5	3.2	0.8	9.0	7.9
	2000-2005	2.5	1.9	0.4	2.7	0.8	8.4	4.3
	2005-2010	2.5	2.0	0.5	3.0	0.8	8.8	7.7
	2010-2015	2.5	2.1	0.5	3.5	0.8	9.3	8.2
Airports	1990-1995	0.5	0.8	1.8	4.8	1.0	8.9	5.1
	1995-2000	0.3	0.9	0.9	3.8	0.8	6.7	3.5
	2000-2005	0.9	0.6	0.9	6.5	1.5	10.4	8.0
	2005-2010	1.3	1.1	1.7	8.6	2.0	14.6	8.7
	2010-2015	1.1	1.3	2.0	11.5	2.7	18.5	10.9
Container Ports	1990-1995							
	1995-2000							
	2000-2005	0.002	0.17	0.49	1.15	0.040	1.85	1.71
	2005-2010	0.003	0.24	0.65	1.56	0.049	2.50	2.33
	2010-2015	0.004	0.36	0.92	2.28	0.063	3.62	3.41
Urban mass-transit	1990-1995							
	1995-2000							
	2000-2005	1.0	1.5	3.7	7.5	0.7	14.4	9.9
	2005-2010	1.4	3.3	5.3	9.6	0.9	20.4	15.6
	2010-2015	1.8	6.2	6.8	14.1	1.0	29.8	24.3

Source: United Nations Economic and Social Commission for Asia and the Pacific. 2006. Enhancing Regional Cooperation in Infrastructure Development including that related to Disaster Management. UNESCAP: Bangkok.

TABLE 2: Descriptive statistics for model 1

Variable	Mean	Std. Dev.	Min	Max
Current/Total exp	.239	.179	0	.830
Capital/Total exp	.062	.056	0	.329
Defense/Total exp	.036	.043	0	.220
Health/Total exp	.018	.022	0	.106
Education/Total exp	.048	.051	0	.256
Transp&Comm/Total exp	.019	.023	0	.136
Total exp/GDP	13.053	13.890	0	70.001
FDI/GDP	2.893	3.839	-5.138	52.132
GDP per capita	2.463	3.538	-16.109	12.444

Number of Observations = 954

TABLE 3: Descriptive statistics for model 2

Variable	Obs	Mean	Std. Dev.	Min	Max
Current/Total exp	720	.247	.174	0	.83
Capital/Total exp	720	.063	.054	0	.33
Defense/Total exp	720	.038	.041	0	.22
Health/Total exp	720	.020	.022	0	.11
Education/Total exp	720	.054	.052	0	.26
Total exp/GDP	720	13.026	13.724	0	53.52
FDI/GDP	720	2.395	3.093	-5.14	20.07
GDP Growth	720	2.299	3.432	-16.11	11.9
Rail	438	8711.406	12664.140	336	63506
Road	533	50.102	31.279	4	100

Table 4: Model 1 with transport infrastructure investment in terms of government expenditure in transport.

Dependent variable = GDP Growth, three-year forward moving average of per capita GDP growth rate.

	OLS Regression	**Fixed-effect**
	GDP Growth	GDP Growth
Current/Total exp	2.442***	3.418***
	(0.708)	(0.943)
Capital/Total exp	-1.03e+01***	-8.399**
	(2.464)	(2.959)
Defense/Total exp	18.603***	14.799***
	(3.267)	(4.254)
Health/Total exp	6.964	2.959
	(6.423)	(7.910)
Education/Total exp	-1.49e+01***	-9.600*
	(3.124)	(4.092)
Transp&Comm/Total exp	24.189***	20.597**
	(6.398)	(7.320)
Total exp/GDP	0.021*	0.033**
	(0.009)	(0.011)
FDI/GDP	0.033	0.029737
	(0.030)	(0.035)
Constant	1.037	1.176*
	(0.562)	(0.494)
Number of Observations	954	954
R-square	0.242	0.235

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 5: Model 2 with transport infrastructure investment in terms of paved roads and rail lines.

Dependent variable = GDP Growth, three-year forward moving average of per capita GDP growth rate.

	OLS Regression	**Fixed-effect**
	GDP Growth	GDP Growth
Current/Total exp	4.630**	5.684**
	(1.591)	(1.883)
Capital/Total exp	-9.835*	-5.719
	(4.459)	(5.629)
Defense/Total exp	8.856	17.581
	(7.845)	(10.878)
Health/Total exp	20.122	25.418
	(11.742)	(15.532)
Education/Total exp	-7.079	-1.76e+01**
	(5.034)	(6.768)
Total exp/GDP	0.042**	0.069***
	(0.016)	(0.021)
FDI/GDP	0.163	0.157
	(0.106)	(0.122)
Rail	0.000	0.000
	(0.000)	(0.000)
Road	0.002	-0.056
	(0.008)	(0.030)
Constant	4.128*	5.557
	(1.665)	(3.761)
Number of Observations	322	322
R-square	0.289	0.312

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 6: Descriptive statistics for robustness check model

Variable	Obs	Mean	Std. Dev.	Min	Max
Current/Total exp	218	.299	.141	0	.827
Capital/Total exp	218	.072	.045	0	.207
Defense/Total exp	252	.048	.047	0	.220
Health/Total exp	252	.024	.024	0	.106
Education/Total exp	252	.063	.053	0	.254
Transp&Comm/Total exp	252	.024	.027	0	.136
Total exp/GDP	252	8.998	11.540	0	70.001
FDI/GDP	252	1.846	2.689	-2.711	18.425
BMP	220	28.134	81.969	-89.161	915.432
GDP Growth	252	2.140	3.009	-7.532	11.452
SHOCK	252	206.864	581.941	-1531.34	2812.994

Table 7 Robustness model

Dependent variable = GDP Growth, three-year forward moving average of per capita GDP growth rate.

	OLS Regression	OLS Regression	Fixed-effect	Fixed-effect
	GDP Growth	GDP Growth	GDP Growth	GDP Growth
Current/Total exp	0.006	1.284	2.023	2.682
	(1.730)	(1.822)	(3.118)	(3.134)
Capital/Total exp	-4.208	1.437	-1.47e+01	-1.06e+01
	(5.837)	(6.121)	(8.261)	(8.602)
Defense/Total exp	1.065	-2.116	-1.94e+01*	-1.83e+01*
	(5.356)	(6.477)	(8.093)	(8.983)
Health/Total exp	17.503	10.114	-1.03e+01	0.867
	(11.892)	(13.127)	(19.850)	(21.384)
Education/Total exp	-1.03e+01	-4.804	12.367	5.152
	(5.609)	(5.862)	(10.041)	(10.772)
Transp&Comm/Total exp	12.112	6.058	2.124	9.460
	(9.914)	(10.662)	(12.271)	(13.113)
Total exp/GDP	-0.002	0.007	0.042	0.030
	(0.017)	(0.018)	(0.028)	(0.031)
FDI/GDP			0.081959	
			(0.076)	
BMP		-0.005		-0.004
		(0.006)		(0.007)
SHOCK		0.0004		0.001**
		(0.000)		(0.000)
Constant	-0.332	0.046	1.106	1.043140
	(1.089)	(1.191)	(1.151)	(1.109)
Number of Obs	218	192	218	192
R-square	0.189	0.184	0.169	0.210

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001