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The Role of Public Investment in Promoting Economic Growth: A case study of Mauritius

Pooloo Zainah

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Name: POOLOO Zainah

*Policy people: Mr Luchmeeparsad, Ministry of Infrastructure
University of Technology, Mauritius
Pointes-Aux-Sables, Mauritius*

Abstract:

This paper employs a reduced form Solow Growth framework to investigate the role of public investment on infrastructure on economic performance for the case of Mauritius over the period 1970-2006. Given the non-stationary characteristics of the data, an error correction model is adopted. Public capital is shown to have significantly contributed to Mauritian economic performance. Moreover results suggest that there may be indirect effects via private capital accumulation and the openness channel as well.

Key words

Public capital, Economic Growth, Vector-error-correction mechanism.

JEL: C32, E32

I. Introduction

An overwhelming number of studies have focused on the link between private capital accumulation and development. In fact the contribution of public infrastructure in the growth process has been largely ignored and has been the focus of only few studies. It should be noted that even then the majority of these studies have been based on an extended Cobb-Douglas specification using static frameworks (refer to Aschauer (1989), Munnell (1990, 1992) for pioneering work). It is only recently that scholars have analysed the hypothesised link using dynamic econometric framework and such works are available from see Pereira and De Fructos (1999), Lighthart (2000), Pereira (2000) and Pereira and Roca Sagales (2003) among others. These studies have treated public input as an unpaid factor and have overall established positive impacts of public capital on economic growth. It should be noted that Tatom (1991), Hulten and Schwab (1993) and Holz-Eakin (1994) have not been able to demonstrate any significant effects of government provided infrastructure as well.

In fact, the majority of the existing literature which attempted to support the public capital-growth hypothesis has been based on developed economies' cases such as US and Western Europe. There is a very scant amount of studies based on developing countries, except Looney (1997) who studied the link for the case of Pakistan and Ghali (1998) for the case of Tunisia. Still then, in the first case public capital was reported not to have been instigating private sector expansion while in the second case public capital were even seen to have a negative effect on private investment and thus output.

The present study attempts to supplement the literature by analysing the link between public capital accumulation and economic growth for the case of an African country namely the island of Mauritius. Mauritius provides an interesting case study as the island is one among the economic success story of the continent where it is claimed that government has been acting as an important support to the development process. The study employs a Solow growth model augmented by two measures of physical infrastructure over the period 1970-2006 to assess the hypothesised link. Dynamic econometric technique is used, namely a Vector Error correction model (VECM), to analyse feedback effects in the system. The paper addresses thus issues pertaining to exogeneity, crowding in and out and causality direction as well. It brings new evidences form the African continent by assessing the productivity of public investment.

The structure of this paper is as follows

Section 2 briefly reviews the literature, both theoretically and empirically, section 3 provides a very concise brief of the Mauritian economy, section 4 deals with the preferred modelling function used and also elaborates on the proxies used and the data

set construction. It also investigates the empirical link between the public capital and economic growth for the case of Mauritius and section 5 concludes and discusses policy implications.

II. Literature review

Theoretical literature

Public capital in infrastructure enhanced private physical capital formation and economic growth because of its impact on private activity. Public spending on infrastructure such as roads, highways, education, sewer and water systems, and power plants often results in a reduction in costs facing the private sector raising the productivity of private capital. By raising the marginal productivity of private inputs, it raises the perceived rate of return on, and increases the demand for, private sector physical capital. Alternatively, a complementarity effect between public capital in infrastructure and private investment may also operate through adjustment costs Turnovsky (1996). This idea is based on the view that the availability of public capital in infrastructure affects some of the costs that firms may incur when investing. For instance, a better road network may reduce expenses associated with the construction of a new factory or the transportation of heavy equipment. By lowering production costs and raising the expected rate of return, public capital in infrastructure may have a strong positive impact on private capital formation. As a word of cautious public investment in infrastructure displaces or crowds out private investment, its net positive impact on private capital formation can be highly mitigated.

Public investment and capital in infrastructure may also affect private capital formation and growth indirectly, through changes in output and relative prices. As noted earlier, public capital in infrastructure may increase the marginal productivity of existing factor inputs, thereby lowering marginal production costs and increasing the level of private production. In turn, as postulated by Chirinko (1993), this scale effect on output may

lead, through the standard accelerator effect, to higher private investment. Public infrastructure can also affect private investment indirectly through its “flow” effect on the price of domestic consumption goods relative to the price of imported goods, that is, the real exchange rate. An increase in public investment in infrastructure for instance will raise aggregate demand and domestic prices. In the eventuality that nominal exchange rate does not depreciate fully to offset the increase in domestic prices it is likely that the domestic-currency price of imported consumption goods will fall in relative terms (real exchange rate appreciation), thereby stimulating demand for these goods and dampening domestic activity. The net effect on output may be positive or negative, depending on the intra-temporal elasticity of substitution between domestic and imported goods. In addition public investment in infrastructure may affect private investment through both demand- and supply-side effects on output. On the demand side, the increase in domestic prices may lower private sector real wealth and thus expenditure. This may in turn lead to a fall in domestic absorption leading firms to revise their expectations of future demand and lower investment outlays, through a “reverse” accelerator effect. On the supply side, the real appreciation may result in a shift in resource allocation toward the non-tradable goods sector which may increase investment in that sector but may however depress capital formation in the tradable goods sector. The net effect may thus be uncertain. There may be an increase in private investment if the nominal exchange rate does not depreciate fully in response to the increase in domestic prices which implies a fall in the real cost of imported intermediate inputs.

Public investment thus plays many competing and offsetting roles in its effect on the investment activities of the private sector, so the net effect of public investment on private investment is an empirical question.

Review of empirical evidence on the effect of Public and Transport Capital accumulation on aggregate productivity and growth

In what follows, we attempt to critically review the existing studies that have assessed the effect of public capital and transport capital development on aggregate productivity and output at a macroeconomic level. However, it is noteworthy that an overwhelming majority studies that have been performed on USA and European countries with very studies indeed pertaining to developing countries and to my knowledge none for Mauritius.

Developed Country cases

Empirical evidence at the National level

Most macroeconomic models have been used in an attempt to find causal relationships between longitudinal changes in the total amount of production inputs, including public capital and transport capital stock and the annual changes in performance of the entire economy or a subset of it. This approach treats infrastructure as a direct injection into the economy, modelled as an additional factor in the aggregate production function, which has the effect of both increasing the level of economic activity and of enhancing the productivity of private capital. This is achieved through public infrastructure acting as a public good.

Aschauer (1989) performed pioneering econometric analysis by trying to correlate the impact of investment in public infrastructure, with productivity and GDP growth for the United States economy over the period 1949 to 1985. He reported that the rate of return of private capital is positively affected by public capital and hence leads to private accumulation. Ashauer found an elasticity of output with respect to public infrastructure capital of 0.4. In fact, he also reported a strong positive relationship between output per unit of capital input, the private labour-capital ratio, and the ratio of the public capital

stock to the private capital input. For instance a 1% increase in the labour-capital ratio brings forth an increase in productivity of capital equal to 0.35%, while a 1% increase in ratio of public to private capital stock raises total factor productivity by 0.39%.

Another major subsequent study was conducted by Munnell (1990, 1992) using more or less the same econometric framework as Aschauer(1989) to assess the contribution of public capital to economic growth. Munnell's model is essentially a production function as well, adjusted for marginal factor productivity (MFP) with public stock (which included transport capital) as an input. She estimated a log-linear form of her model for US data (1948-87) and reported that the elasticity of labour productivity with respect to public capital ranges from 0.31 to 0.39 (that is a 10% increase in public capital would raise productivity by 3.1 to 3.9%). Based on her estimates for the period 1970-1990, she concluded that a 10% increase in public capital was to increase aggregate output by 1.4%. From these estimates, most of the increase in aggregate output was due to an increase in factor productivity.

It should be emphasized that one essential problem with both Aschauer's and Munnell's work and with most other subsequent works was that they could not successfully rule out the possibility that the causal direction might run from growth to infrastructure, that is higher income generating more demand for transport services and thus capital. In such cases, the causal direction is reversed as the present state of high growth stimulates infrastructure investment. Disregarding such causality possibilities might result in problems of simultaneity in the empirical analysis, which in turn might have generated wrong estimates.

Based on similar empirical techniques, some other subsequent studies concluded that the original results of the impact of public might have been exaggerated. Tatom (1991a) for instance argued and rightly so that the elasticity found by Aschauer is too high to be plausible. He pointed out that the econometric analysis of Aschauer might in fact have a

flaw in that the time series used were non-stationary. He also claimed that the results also revealed spurious correlation leading us to believe that some other unspecified variables were perhaps missing. Tatom (1991a), using public capital data from Aschauer (1989a), re-estimated the regression from Aschauer (1989a) with variables in first differences, as the data were non-stationary according to him, and also including an energy prices variable to control for oil price shocks. He found that public capital turned out to be insignificant.

Subsequent, studies from Aaron (1990), Hulten and Schwab (1993) and Douglas Holtz-Eakin(1994) also tend to confirm the above. In the words of Krugman, Aschauer's findings are "more of a matter of correlation than causation" (Krugman (1994)). Denon and Eberts (1991) observed that there could have diminishing returns to transport investment and that results could even turn out to be negative in the extreme, especially after some threshold levels.

However, recent waves of studies tend in general to support the positive contribution of public capital on economic progress. For instance, in a review of 15 regional studies during the period 1985-1995 on the transportation effects on economic development, Fisher (1997) observed that the positive effect of highway facilities or spending on economic development is reported in 10 of the studies(or nearly 70%), with effect being statistically significant in 8 of cases. He warned, though, that most of these studies were based on USA and at state level and also overlooked the causality aspect of the relation.

Pereira and De Frutos (1999) investigated the empirical link between public capital and the private variables, namely the economy's output, private investment and employment level in the US context using recent vector autoregressive (VAR) framework. They changed the terms of the debate by arguing that a single equation framework excludes the possibility of dynamic feedbacks. Their results showed that a one-dollar increase in public capital increases long term output by 65 cents. A positive

relationship was also registered between public and private capital (crowding in effects) and employment as well. In the same line, Pereira (2000) further made use of an extended annual data set (1956-1997) to establish the relationship between public investment and private sector performance for the US case in a VAR framework. The author confirmed that all types of public investment are indeed growth conducive. Moreover the core infrastructure (electric and gas facilities, transit systems and airfields, sewage and water supply system) were reported to be the most productive of these investment. Educational, hospital and other public buildings registered lower rates of return but were also believed to be important factors.

Other studies alternatively used the cost function approach to model the benefits of public capital and transport capital. Among the most famous studies features Nadiri and Mamuneas (1991) who, using a translog cost function model, reported that elasticity of costs with respect to public infrastructure expansion ranges from -0.11 to -0.22. The model was applied to USA data in the manufacturing industries.

There exists numerous studies assessing the hypothesised link based on non-US countries. For instance Christodoulakis (1993), in his study of the economic assessment of public infrastructure to the manufacturing sector in Greece during the period 1963-1990 reported that public capital in general could have explain between 27- 42% of the increase in manufacturing output. Using the same approach, Bajo-Rubio and Sosvilla-Rivero (1993), using time series for the period 1964-1988 in Spain, concluded that a 1% increase in the stock of public infrastructure would lead to 0.18% increase in national income.

Denny and Guiomard (1997), for the period 1951-1994 in Ireland specified a Cobb-Douglas and an auto-regressive function and concluded that an output elasticity of transport capital of 0.92 was computed. Such a high value seems doubtful and too high

to be plausible and a closer look at the study revealed that the model could have in fact been mis-specified.

Sturm, Jacobs and Groote (1996) examined the impact of infrastructure investment on the Netherlands economy for the sample period of 1853-1913 (pre war period). The authors used a Granger-causality tests in a Vector Auto Regression (VAR) framework. They found a significant positive effect of infrastructure on GDP and also that there existed a uni-directional relationship between infrastructure and GDP. Moreover decomposing infrastructure as basic (railroad, roads, harbour, drainage etc) and complementary (gas, electricity, water supply), they observed that only basic infrastructure seems to have a long run benefit on the economy with complementary infrastructure (the biggest portion of Netherlands's economy) having short run effects. However, they found that no relationship existed between machinery and infrastructure, thus not confirming that infrastructure increases GDP through an indirect effect on machinery (private capital).

Lighthart (2000) studied the effect of public capital on growth in Portugal using annual data for the period 1965-95 in a general form production function. The model's estimation result yields an elasticity of public output amounting to 0.20, that is, a 1 % increase in the public capital stock raises GDP by 0.20 %. Output elasticity of labour was of the magnitude of 0.67 and that of private capital to 0.37. The author subsequently employed an unrestricted vector auto regression model to test the relationship. The results tend to confirm those obtained previously.

It should also be pointed out that some studies did not confirm the positive and significant relationship between public infrastructure and transport capital to growth. One earlier regionally focused study (Owen-Smith (1984)) found little relationship between the levels of investment in roads in the UK regions and rates of economic growth. The Aschauer (1988) model was also applied in Europe by Ford and Poret

(1991) and their study revealed mixed results that offered inconclusive evidence that transportation development and productivity and economic development were linked.

Empirical evidences at developing countries' level.

Few studies are available for the developing countries' level regarding the contribution of transport capital to productivity and development. This is even more scarce for African and small island country's case. This has been mostly due to lack of availability of data. We shall review in first instance a couple of studies by Looney (1997) and Ghali (1998)¹ which received good praise in the literature.

Looney (1997) investigated the role of infrastructure in explaining Pakistan's economic progress over the period 1973-1990. He analysed the effects of several types of public infrastructure (General, Energy, Transport and Local) on the country's private investment level and long term growth. Using a VAR methodology, he found that public capital has played a rather passive role in Pakistan's development. In fact, using variance decomposition analysis, it was reported that 18% of the variance of the GDP accounted for innovation in private investment with only 1.5% from general infrastructure. As far as private investment's variance is concern, infrastructure accounted for just less than 5% of it. The other three types of public infrastructure yielded the same result. It was concluded that public infrastructures have not been instigating private sector expansion but has been rather a response to the needs of the sector.

Ghali (1998) analysed the long run relationship between public investment, private capital formation and output for Tunisia over the period 1963-93. He used recent multivariate co-integration techniques and developed a vector-error-correction model using a Cobb-Douglas production function framework. The error-correction model

¹ An interested reader can also refer to Deichmann, Fay, Koo and Lall (2002) for a study of the Mexican case.

(ECM) and ECM based causality techniques tend to confirm that public investment has a negative and significant effect on private investment with two time lags. The author argued that crowding out probably exists and that maybe this negative link could also be explained by the fact that public investment is undertaken by heavily subsidised and inefficient state owned companies. Moreover, concerning the link between private and public investment and growth in Tunisia, Ghali (1998) found that neither of these investments explains economic performance. This are indeed quite surprising conclusion, but the author himself admitted that ' these results are in accordance with the fact that the Tunisian private sector is not yet sufficiently developed to take the lead and promote economic growth.'

Section II: Public Investment in Mauritius

As far as public capital investment² is concerned, the government, despite the worst economic phase of our economic history in the decade 1960-70, had to raise its capital expenditure (to 4.2% of GDP) during this period partly due to the aftermath of the Carol cyclone and also to compensate to some extent the drop in the private sector's investment. The highest public investment rate came in the 1980-1990 decade when it reached a decade average of about 5% of GDP and again coinciding with the 1980-1990 boom period. The high level of public investment could have probably attracted both inward and foreign direct investment. However during the last decade public investment has dropped to a decade average of about 2.2% despite an average rate of total investment of 13.5%³. It is instructive to note that over the past 50 years, the volatility of public investment has been on the high side and might indicate that the government decision to spend on capital projects could have been on an adhoc basis.

² Public investment on average (over the whole period) is about 30-35% of total investment. It should be stressed that it also has a high standard deviation across time.

³ Diagrams 4.1 and 4.2 provide a graphical depiction of the private and public investment value and rate over the period of study.

Table 1: Public Capital in Mauritius

	Average 1950-60	Average 1960-70	Average 1970-80	Average 1980-90	Average 1990-2000
GDP growth	1.35%	1.61%	11.28%	11.7%	5.75%
Total Investment/GDP	14.12	11.8	13.1	14.7	13.5
Private Investment/GDP	10.64	7.6	10.3	10.4	11.3
Public Investment/GDP	3.48	4.2	4.8	4.3	2.2
Non-Transport investment/GDP	2.7	3.24	4.32	3.8	1.95
Transport investment/GDP	0.78	0.96	0.48	0.5	0.25

III. Methodology and Analysis

Dynamic feedback issues and VAR

Our analysis employs an economic growth function duly extended for the purpose of the paper in a dynamic econometric framework, namely a Vector Autoregressive (VAR) model. The latter approach has been used in numerous studies (see King and Levine (1993), Levine and Zervos (1998), Pereira and Roca Sagales (2003), Khadaroo and Seetanah (2007, 2008) among others). The VAR framework importantly accounts for the possibility of dynamic feedbacks among variables. In fact, public capital affects a country's output not only directly but also indirectly, via private capital for instance. Moreover the income level of a country can also translate into the creation of more public capital.⁴

⁴See Pereira and De Fructos (1999) and Lighthart (2000) for a complete treatment of feedback effects.

Model Specification and preliminary tests

We extend a classical economic growth function and the implied theoretical model is as follows

$$OUTPUT = f(PRIIVT, ROADS, COM, OPENNESS, EDUCATION) \quad (1)$$

OUTPUT denotes the economy's output, *PRIIVT* is the private capital, *ROAD* and *COM* are respectively the transport and non transport capital stock, *OPENNESS* is the proxy for openness and *EDUCATION* is the secondary enrolment ratio and accounts for the quality of labour.

Data construction and sources

We use the sum of exports and imports divided by GDP as a measure of *OPENNESS*. *EDUCATION* is the secondary enrolment ratio and proxies for the quality of human capital. The dependent variable, *OUTPUT*, is real Gross Domestic Product. These data series were available from the Central Statistical Office (CSO) and from the Bi-annual Digest of Statistics over the period 1970 – 2006.

PRIIVT is measured as the ratio of private investment to GDP and measures level of private investment including FDI in the country.

We use *road* (length of paved road per square kilometer) and *com* (number of telephone lines per 1000 inhabitants) to proxy the infrastructure. The measure for transport infrastructure has been used in the literature namely by Canning (1999), Canning, and Bennathan, (2000) and the data was available and constructed from Canning (1999) database, the International Road Federation (IRF), and also from various countries' Central Statistical Office. Telephone lines measure on the other hand is consistent from the work of Loree and Guisinger (1995), Asiedu (2002) and Alam and Quazi (2003) among others. Canning (1999) data base and World Development Indicators (various issues) provided the source for this data.

The Econometric Model

For the econometric analysis, equation (1) is expressed as a log-linear regression, where lowercase variables are the natural log of the respective uppercase variables:

$$output = \alpha + \beta_1 priivt + \beta_2 road + \beta_3 com + \beta_4 openness + \beta_5 education + \varepsilon \quad (2)$$

Here below we investigate the univariate properties of the data series and to determine their order of integration. We employed the Augmented Dickey-Fuller (ADF) (1979) and Phillips-Perron (PP) (1988) unit-root tests. The results are summarised in Tables 1 and 2 below.

Table 1: Summary results in level form: Augmented Dickey-Fuller and Phillips-Perron

Tests

<u>Variables</u> (in natural log)	<u>Lag</u> <u>selection</u>	<u>ADF</u>	<u>PP</u>	<u>Critical</u> <u>Value</u>	<u>Variable</u> <u>Type</u>	<u>ADF</u> (t)	<u>Critical</u> <u>Value</u>	<u>Variable</u> <u>Type</u>
<i>output</i>	1	+1.42	+2.51	-2.92	<i>I(1)</i>	-2.4	-3.5	<i>I(1)</i>
<i>priivt</i>	1	+1.15	-2.283	-2.92	<i>I(1)</i>	-1.32	-3.5	<i>I(1)</i>
<i>roadt</i>	1	-1.13	-0.85	-2.92	<i>I(1)</i>	-1.15	-3.5	<i>I(1)</i>
<i>com</i>	1	+0.96	+2.96	-2.92	<i>I(1)</i>	-0.75	-3.5	<i>I(1)</i>
<i>openness</i>	1	-1.54	-0.54	-2.92	<i>I(1)</i>	-0.32	-3.5	<i>I(1)</i>
<i>education</i>	1	-1.12	-0.34	-2.92	<i>I(1)</i>	-0.52	-3.5	<i>I(1)</i>

Table 2: Summary results in first difference: DF and PP Tests

<u>Variables</u>	<u>Lag</u> <u>selection</u>	<u>ADF</u>	<u>PP</u>	<u>Critical</u> <u>Value</u>	<u>Variable</u> <u>Type</u>	<u>ADF</u> (t)	<u>Critical</u> <u>Value</u>	<u>Variable</u> <u>Type</u>
Δ <i>output</i>	0	-8.53	-8.78	-2.9	<i>I(0)</i>	-8.92	-3.5	<i>I(0)</i>
Δ <i>priivt</i>	0	-8.75	-5.2	-2.9	<i>I(0)</i>	-8.65	-3.5	<i>I(0)</i>
Δ <i>road</i>	0	-4.23	-3.34	-2.9	<i>I(0)</i>	-4.56	-3.5	<i>I(0)</i>
Δ <i>com</i>	0	-4.72	-3.4	-2.9	<i>I(0)</i>	-5.112	-3.5	<i>I(0)</i>
Δ <i>openness</i>	0	-4.245	+3.4 4	-2.9	<i>I(0)</i>	-4.41	-3.5	<i>I(0)</i>
Δ <i>education</i>	0	-4.75	-2.92	-2.936	<i>I(0)</i>	-5.01	-3.5	<i>I(0)</i>

The above results imply that our variables are all integrated of order 1 ($I(1)$) and are thus stationary in first difference. Analysis of cointegration among the six variables was then undertaken using the Johansen Maximum Likelihood procedure. The results are reported in Table 3 below.

Table 3: Results from Johansen procedure

	Null Hypothesis	Alternative Hypothesis	Test Statistic	Critical Value 5%	Critical Value 10%
<i>Maximal eigenvalue of the stochastic matrix</i>	$r=0$	$r=1$	50.3	36.2	33.4
	$r\leq 1$	$r=2$	24.3	29.9	27.5
	$r\leq 2$	$r=3$	12.8	23.2	21.5
	$r\leq 3$	$r=4$	15.2	17.6	15.5
	$r\leq 4$	$r=5$	7.3	11.0	9.2
	$r\leq 5$	$r=6$	2.3	4.16	3.0
<i>Trace of the stochastic matrix</i>	$r=0$	$r\geq 1$	96.34	83.1	78.4
	$r\leq 1$	$r\geq 2$	44.34	59.3	55.4
	$r\leq 2$	$r\geq 3$	33.34	39.8	36.6
	$r\leq 3$	$r\geq 4$	13.34	24.0	21.4

	$r \leq 4$	$r \geq 5$	4.34	12.3	10.2
	$r \leq 5$	$r = 6$	1.34	4.1	3.0

Based on a VAR of order 2, suggested by the Schwarz Bayesian criterion (SBC), both the Maximum Eigenvalue test and the Trace test reveal the presence of one cointegrating vector. Engle and Granger (1987) showed that cointegration implies an error-correction mechanism (ECM). We accordingly formulated the VAR as a Vector Error Correction model (VECM) to capture short-run dynamics in addition to the long-run equilibrium.

The Vector Error Correction Model

For the present analysis the VAR consists of 6 endogenous variables all integrated of order 1, and contained in:

$$Z_t = [output_t, privt_t, road_t, com_t, openness_t, education_t]$$

Since the Johansen procedure indicated the existence of one cointegrating vector, we proceeded with a Vector Error Correction Model (VECM) formulation.

$$\Delta Z_t = \Gamma_1 Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \dots + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi Z_{t-1} + \mu + \eta_t \quad t=1 \dots T \quad (4)$$

ΔZ_t is a vector of growth rates, the Γ s are estimable parameters, and η_t is as defined under equation (3). Π is the long-run parameter matrix with rank equal to r , in our case 1. Given the presence of cointegration, the matrix Π has non-zero but less-than-full

rank and can be decomposed into $\alpha\beta'$, where β is a matrix of long-run parameters and α is a matrix of short-run adjustment parameters.

Empirics and Analysis

The estimated cointegrating vector, normalized on output, and the estimated adjustment parameters are presented in Table 4.

Table 4 : Long Run Estimates

<i>Variables</i>	β	<i>t-ratios</i>
<i>output</i>	1	
<i>priivt</i>	0.763***	4.74
<i>road</i>	0.221**	2.34
<i>com</i>	0.321*	1.86
<i>openness</i>	0.523**	2.12
<i>education</i>	0.453***	2.27

*significant at 10%, ** significant at 5%, ***significant at 1%

Transport infrastructure has a positive significant effect on output in Mauritius in the long-run, with an implied elasticity of 0.221 which is consistent with the range reported in the literature. A positive effect is also observed for communication infrastructure, yielding a higher output elasticity of 0.3621. Private capital, as expected, is the most

productive. The other determinants, namely openness (*openness*) and quality of labour (*education*), are seen to have a positive impact, again in line with the literature.

Estimates of the VECM

The VECM was then estimated. The error-correction equations are not subject to residual autocorrelation at the 5% significance level. The Wald test indicates that the variables are not weakly exogenous at the 5% significance level. The lagged error-correction terms are significant in all the equations of the VECM. Therefore the variables in the system are all endogenous. The regression results appear in Table 5.

Table 5: Estimates of the VECM

<i>Variables</i>	$\Delta output$	$\Delta priivt$	$\Delta road$	Δcom	$\Delta openness$	$\Delta education$
<i>Constant</i>	-1.23***	1.432***	-0.45*	-0.234	2.23*	0.623**
$\Delta output_{t-1}$	-0.153	0.121*	0.12	0.343	0.322*	0.234**
$\Delta priivt_{t-1}$	0.533***	0.7045***	0.053	0.122	0.16*	0.072
$\Delta road_{t-1}$	0.132**	0.095**	0.524**	-0.142*	0.222*	0.034
Δcom_{t-1}	0.198**	0.134**	-0.11*	0.262*	0.311*	0.164
$\Delta openness_{t-1}$	0.312**	0.222*	0.233*	0.143*	0.665*	0.0021
$\Delta education_{t-1}$	0.211**	0.134	0.155	0.042	0.223*	0.434**
v_{t-1}	-0.36***	0.246***	-0.134*	-0.16**	-0.366	0.345**
R^2	0.73***	0.723	0.532	0.343	0.363	0.43

*significant at 10%, ** significant at 5%, ***significant at 1%

The above results (column 2) reveal a positive significant contribution of transport capital to output in the short-run. The short-run output elasticity of 0.145 is lower than its long-run counterpart, suggesting that it might take some time for transport capital to be fully operative in an economy. A 1 percentage-point increase in the growth rate of transport capital leads to a 0.13 percentage-point increase in the growth rate of output after one year. This is an estimate of the direct effect of transport capital on output in the short-run. Private capital, non-transport capital, openness and quality of labour are all significant in explaining the short-run variation in output. Moreover 36% of an existing disequilibrium is corrected in the next period, implying a moderate speed of adjustment.

A 1 percentage-point increase in the growth rate of transport capital leads to a approx 0.1 percentage-point increase in the growth rate of private capital after one year. A 1 percentage-point increase in the growth rate of private capital leads to a 0.5 percentage-point increase in the growth rate of output after one year. The latter two pieces of information taken together imply that a 1 percentage-point increase in the growth rate of transport capital leads to a 0.05 percentage-point increase in the growth rate of output after two years. This is an estimate of the indirect effect of transport capital on output in the short-run via the private capital channel. As such indirect effects through the openness channel are also observed.

Moreover the positive significant coefficients of transport and communication in the private capital error-correction equation (column 3) support the crowding-in hypothesis. As such important bicausal relationships between private investment and growth and also between openness and growth are observed. This confirms the presence of reinforcing effects as far as these two variables are concerned. However such are not observed for the case of both infrastructure measures thus suggesting that decision to invest in public capital is exogeneous by nature.

ECM-based Causality tests

ECM-based causality tests were performed on various pairs of causal effects. With regard to whether transport capital Granger-causes economic performance, the test rejected the null hypothesis of non-causality. This implies a Granger-causality effect from transport capital to GDP.⁵

It is also useful to examine whether the island's GDP Granger-causes transport capital, that is, bi-directionality. The test favoured the acceptance of the null hypothesis thus confirming non-causal effects from growth to transport capital. So it would appear that decisions to invest in transport capital seem to be independent of the state of the economy. Similar results were observed when testing whether the GDP of the island Granger-causes non-transport capital. However, evidence of bi-directionality is obtained in the case of output and private capital accumulation,

⁵ Block causality test was also performed and tends to confirm the results.

Further analysis was also undertaken to investigate whether transport investment Ganger-causes private investment. It could be deduced that transport investment indeed attracts private investment, thus confirming indirect and feedback effects. However we could not establish causality from private to transport capital accumulation. This yet again tends to reveal that government does not base itself on private investment level for transport investment. Public capital decisions are more or less seen to be independent decisions. It should be noted that communication capital is also seen to positively impact on private investment. However we could not find evidence for the reverse. Causality between transport and communication capital was also investigated and the test indicated that there might be crowding out effect as they might be competing for limited government funding.

Summary of results

The link between public capital, as measured by transport and communication infrastructure, and economic performance has been analysed in a multivariate dynamic framework allowing for feedbacks. Results from the analysis reveal that both public capital have been important elements, although not as important as the other types of capital, in the economic progress of the Mauritian economy. In fact both positive significant short-run output elasticity and long-run output elasticity with respect to transport and communication capital were observed. It is also further observed that

these capital may be taking some time to have its full effects. We find that transport and communication capital have positive impacts on private sector capital accumulation (crowding in effects). However we could not establish feedback effects from output level and private capital to transport and communication capital.

4.1 Policy Implications

Infrastructure in Mauritius has been driven by ad hoc considerations having no explicit focus on long-term requirements. Officials and planners have often been unable to make clear decisions regarding the use of limited public funds in public capital investment in the absence of solid empirical findings. This is particularly true as in times of budget crises the government has often responded by cutting expenditures on these capital. The results of this study might thus assist in a better and more efficient allocation of government budget, in particular with regard to infrastructure spending. We would recommend that government refrains from drastic cuts, particularly in infrastructural capital expenditure, even in difficult times. The government might consider to extend their infrastructural and developmental loans from the World Bank and other international institutions instead of proceeding with capital expenditure cuts in the budget.

It is evident that the case of private financing and joint public/private financing arrangements is more than established. In fact government should ensure that the

private sector has sufficient incentives to invest in infrastructural capital and in its services as well. Indeed government needs to develop an efficient institutional framework and a conducive environment. These include the legislative and regulatory environment, namely formulating a Build-Operate-Transfer (BOT) law, removing unnecessary bureaucratic procedures and practices, and marketing the potential of Mauritius to the international investor community.

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