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Roads versus Schooling: Growth Effects of Government Choices

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Abstract

This paper studies the growth effects of productive public expenditures on education and public capital in an endogenous growth model of overlapping generations. The model is calibrated to Latin American data, and the effects of raising government expenditures on education and public capital are computed. Results show that increases in these public expenditures have moderate, positive effects on per capita growth and income under different scenarios. In addition, re-allocating expenditures from public capital to education while keeping the budget constant can raise growth up to a threshold.

KEYWORDS: productive public expenditures, growth, public capital, education

1 Introduction

One of the key implications of endogenous growth models is that public policy can affect the long-run growth rate of a country. Specifically, there has been recent interest in studying how productive government expenditures affect economic growth. Productive public expenditures are expenditures that affect some of the inputs of a country's production function. The two expenditures of this type that have received the most attention are on public capital and public education. Government spending on public capital goes to build roads, water systems, and power generating facilities which are then available to be used by private sector productive activities. Similarly, government spending on education goes to fund texts, teachers, and classroom equipment which help raise literacy rates and human capital levels in the country, and hence productive capacity.

There have been several theoretical contributions in this literature. For instance, Barro (1990) and Glomm and Ravikumar (1994) analyzed the effects of public capital on growth. These papers model public capital as another input in the production function.[1] In subsequent research, Glomm and Ravikumar (1997) analyzed both the effects of government spending on public capital and education in an overlapping generations model. In their model, education spending is an input in the human capital production function.[2] While this literature has been successful in pointing out the channels and potential effects qualitatively, there have been few quantitative-theoretic analysis of the effects of productive public expenditures. A quantitative-theoretic framework uses a fully specified micro-foundations model that is calibrated to match salient data features of an economy. With this approach, the effects of policy changes can be computed and their economic significance evaluated as proposed by Lucas (1987). Along these lines, Rioja (1999, 2003) concentrates on the quantitative effects of public infrastructure focusing on Latin America. Domenech and Garcia (2002) study optimal fiscal policy in a

[1]Other work in this vein includes Devarajan, Xie, and Zou (1998), Jones, Manuelli, and Rossi (1993), and Turnovsky (1997, 1999). There is also a large empirical literature starting with Aschauer's (1989) seminal paper which studies U.S. data. Cross-country and developing country studies include Canning (1998, 1999), Canning and Fay (1993), Demetriades and Mamuneas (2000), Easterly and Rebelo (1993), and Fay (2001). Other U.S. studies include Batina (1999), Fernald (1999), Holtz-Eakin and Schwartz (1995), Nadiri and Mamuneas (1994), Munnell (1992), and Morrison and Schwartz (1996).

[2]For empirical studies of the effects of education quality, see Krueger (1968), Hanushek (1986), and Card and Krueger (1992).

model calibrated to OECD countries where the government provides public capital and public consumption goods. Similarly, Baier and Glomm (2001) and Cassou and Lansing (1998) calibrate their models to the post-war U.S. experience and analyze various fiscal policies.

This paper evaluates the quantitative effects and tradeoffs of *both* public capital and education expenditures. Specifically, the paper tries to answer:

- How large can the growth effects be of increasing these two types of productive public expenditures, either separately or in conjunction?
- What are the growth effects of re-allocating expenditures between these two activities while keeping the budget constant?

As these questions are of crucial importance for developing countries, the analysis concentrates on seven Latin American countries. Given their tight public budgets, policymakers in these countries are interested in the answer to these questions and the potential impact of changing or reallocating expenditures.

The theoretical foundation is an endogenous growth model of overlapping generations. In the model, the government provides public capital available to all firms, and it also spends on education therefore affecting the quality of schooling. Schooling is one determinant of the human capital that individuals accumulate. The government raises revenue by taxing labor and capital income. The model is solved and calibrated using data and estimates for seven Latin American countries. Robustness checks with best and worst case scenarios are computed. Results show that an additional 1% of GDP devoted to education expenditures above benchmark levels increases the per capita growth rate by about 0.10 percentage points. As growth is compounded, such expenditures changes can have large implications for per capita income levels of successive generations. Additional expenditures on public capital are also found to raise growth, although by less than education. In this regard, shifting expenditures *from* public capital *to* education, without raising additional funds, can increase growth rates up to a certain threshold.

The organization of the remainder of the paper is: Section 2 describes the model and Section 3 the quantitative evaluation. The results are presented in Section 4 and Section 5 concludes.

2 Model

The theoretical framework uses a Diamond (1965)-type overlapping generations model, which was adapted to include public capital and education expenditures by Glomm and Ravikumar (1997). The key feature is that the government can affect the production function by those two types of productive expenditures. Individuals live for two periods and the size of each generation is normalized to unity. Individual preferences are described by

$$\ln c_t^t + \beta \ln c_{t+1}^t, \tag{1}$$

where $\beta \in (0,1)$, superscripts denote an individual born in time t, and subscripts denote consumption when young (at time t) and when old (at time $t+1$).

Individuals accumulate human capital, h_t, as follows:

$$h_t = B h_{t-1}^{\nu} E_t^{\mu}, \tag{2}$$

where B is a fixed shift parameter. Hence an individual's level of human capital at time t is a function of public spending on education (E_t) and time $t-1$ human capital level (h_{t-1}). This can be interpreted as an individual's educational level depending on school quality and the parents' education level.

Firms produce output according to a Cobb-Douglas type function:

$$y_t = A \widehat{G}_t^{\theta} k_t^{\alpha} (n_t h_t)^{1-\alpha} \tag{3}$$

where $\alpha, \theta \in (0,1), A > 0$. Private physical capital is denoted k_t, "effective" public capital is denoted $\widehat{G}_t$. Labor is denoted n_t, which we will assume is inelastically supplied and normalized to unity, so $n_t h_t$ is the effective labor input. Public capital is a rivalrous public good provided by the government and available to all firms. That is, public capital is subject to congestion with usage. Following Stiglitz (1988) and Glomm and Ravikumar (1994), this is formally modeled according to,

$$\widehat{G}_t = \frac{G_t}{K_t^{\gamma} H_t^{\psi}}.$$

The raw stock of public capital, G_t, is congested by use as private sector activity increases, which is proxied by the economywide levels of physical and human capital, K_t and H_t (γ, ψ are parameters such that $\gamma > 0, \psi > 0$, and $\gamma + \psi < 1$).

The firm's problem is to maximize profit according to:

$$\max_{k_t, h_t} A\widehat{G}_t^{\theta} k_t^{\alpha} (n_t h_t)^{1-\alpha} - w_t n_t h_t - q_t k_t$$

where q_t is the rental rate of capital and w_t is the wage rate. The first order conditions for the firm's maximization problem are standard: $q_t = \alpha y_t / k_t$ and $w_t n_t = (1-\alpha) y_t / h_t$. Given the constant returns to scale to private factors, profits in equilibrium are zero.

The young individual's maximization problem is

$$\max_{\{c_t^t, c_{t+1}^t\}} \ln c_t^t + \beta \ln c_{t+1}^t \tag{4}$$

subject to

$$\begin{aligned} c_t^t + s_t^t &\leq (1-\tau) w_t n_t h_t \\ c_{t+1}^t &\leq [1 + (1-\tau) r_{t+1}] s_t^t. \end{aligned} \tag{5}$$

Hence, the individual faces two budget constraints one when young and one when old. When young, he or she must decide how much of net-of tax labor income is allocated between consumption and saving, s_t^t. When old, the individual's consumption is bound by his or her net-of-tax return to savings. Labor and capital income are both taxed by the government at a flat rate τ.

The government uses tax revenues to invest in public capital, I_t^G, and spend on education, E_t. Hence, the government's budget constraint is,

$$I_t^G + E_t = \tau(w_t n_t h_t + r_t k_t). \tag{6}$$

which must be balanced every period. The government also allocates a fixed percentage, m, of total revenues to education expenditures and $(1-m)$ to public investment. Hence, $E_t = m\tau(w_t n_t h_t + r_t k_t)$ and $I_t^G = (1-m)\tau(w_t n_t h_t + r_t k_t)$.

Public capital is accumulated according to

$$G_{t+1} = I_t^G \tag{7}$$

This implies that the depreciation rate of public capital is assumed to be unity for simplicity and tractability. This assumption is adopted uniformly for private physical capital and human capital as well.[3]

The solution to the individual's maximization problem (maximize equation (4) subject to the constraints in (5)) yields an optimal savings of

$$s_t^t = \frac{\beta(1-\tau)w_t n_t h_t}{1+\beta}. \tag{8}$$

Since $k_{t+1} = s_t$ in equilibrium,

$$k_{t+1} = \frac{\beta(1-\tau)(1-\alpha)A\widehat{G}_t^{\theta} k_t^{\alpha}(n_t h_t)^{1-\alpha}}{(1+\beta)}. \tag{9}$$

This equation can also be used to explain the effects of public investment intuitively. For example, raising public capital expenditures (G) would exert a positive effect on private physical capital accumulation (k_{t+1}) in equation (9). However, such raise would have to be paid for by higher taxes. Then, raising τ in equation (9) would have a negative effect on k_{t+1}. Which effect dominates and how large the *net* effect can be must be established by formally solving the model quantitatively. Due to the complications of having both public capital and public education, as well as congestion of public capital, an analytical solution for the growth rate cannot be obtained for this model.[4] Consequently, it is also not possible to check *analytically* for transitional dynamics. In a similar model, Glomm and Ravikumar (1997) show analytically that there are no transitional dynamics. Regarding the present paper, the indication from the numerical work in the following sections is that there are no transitional dynamics as growth rates are found to not depend on changing starting values of the capital stocks. The dynamics of the system are controlled by equations (2), (7), and (9).[5] In order to solve this model quantitatively, parameter values must be chosen next.

[3] This may be a reasonable assumption since one time period is a generation, which is taken to be 30 years in the quantitative section.

[4] Glomm and Ravikumar (1997) do compute a growth rate analytically, but to do so they only focus on one of the public expenditures at a time. That approach, however, would not highlight the tradeoffs and interactions of both expenditures which is the focus of the present paper.

[5] In addition, given the representative firm framework, $K_t = k_t$ and $H_t = h_t$.

3 Quantitative Evaluation

The quantitative evaluation focuses on the seven largest economies in Latin America: Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela. One advantage in choosing these countries is that Elias (1992) has analyzed their growth accounting thoroughly. In the calibration, a generation will be taken to be 30 years. The initial generation in the model is calibrated so that it matches with the observed data features in these countries in the 1970 to 1999 period. Consider the data in Table 1. In constant dollars, the average GDP per capita in 1970 was \$3,132 and \$4,162 in 1999. Real per capita GDP grew 1.30% per year on average over this same period.

Table 1
Latin American Economic Performance and Public Expenditures

Country	GDP[a]		Growth[a]	Pub. Investment[b]	Education[c]
	1970	1999	1970-1999		
Argentina	\$6,830	\$8,100	0.76	7.20	2.65
Brazil	\$4,254	\$4,480	2.41	7.05	1.89
Chile	\$2,360	\$5,121	1.84	6.95	3.86
Colombia	\$1,377	\$2,261	2.80	6.05	2.20
Mexico	\$2,295	\$3,613	1.70	7.45	2.96
Peru	\$2,359	\$2,346	0.22	5.20	2.62
Venezuela	\$4,305	\$3,213	-0.70	11.0	4.09
Average	**\$3,132**	**\$4,162**	**1.30**	**7.27**	**2.90**

Sources: a. per capita. World Development Indicators, 2002 CD-Rom.
b. as percent of GDP. Easterly and Rebelo, 1993.
c. as percent of GDP. Government Financial Statistics, 2001.

Table 1 also presents data on the productive public expenditures of interest. Public investment as a percent of GDP averaged about 7.27% according to Easterly and Rebelo (1993). While Easterly and Rebelo's data covers the 1970s and 1980s decades and not the 1990s, this study is still the most consistent across countries as it deals with the various problems in reporting public investment data. In addition, the public investment share shown is net of any education-related expenditures like school buildings. Education expenditures are obtained from Government Financial Statistics (GFS, 2001) and cover roughly the 1970-99 period. These seven countries spent an average of 2.9% of GDP on education. The choice of several benchmark parameters discussed below reflects this data.

Table 2 presents the parameter choices for the benchmark calibration of the model. Following the data on Table 1, the tax rate τ, which reflects the percent of GDP spent on public investment *plus* education, is set to 0.102 or 10.2% (7.27% on public investment + 2.90% on education). Then, the share of total tax receipts that are allocated to education, m, is set to 0.284 (2.90/10.2).

Table 2
Benchmark Parameters

Parameter	Value	Description
τ	0.102	tax rate
m	0.284	education share
θ	0.15	public capital coefficient
γ	0.015	congestion parameter
ψ	0.015	congestion parameter
μ	0.10	education spending coefficient
ν	0.842	lagged human capital coefficient
α	0.60	capital share
β	0.40	discount factor
A	6.15	shift parameter
B	2.0	shift parameter

Next, the public capital coefficient in the production function, θ, is of key importance. As there are no specific estimates for these seven countries, we use an average of various estimates. This parameter has been estimated as large as 0.20 by Fay (2001) and Canning and Fay (1993) using large cross country data sets. Hulten (1996) estimates it around 0.10 using data from low- and middle-income countries, including six of the seven Latin American countries of interest. Canning and Bennathan (2000) also estimate it at about 0.10. We take the midpoint of these estimates and set θ to 0.15 in the benchmark. Of course, robustness checks will subsequently explore the effects of changing this parameter within the range in the literature.

According to the 1994 World Development Report, public capital in developing countries is congested by about 20%. Hence, the effective stock of public capital is only 80% of the raw stock. The congestion parameters γ and ψ are set to 0.015 to generate this level of congestion.

Regarding the education production function, Hanushek (1986, 1996) and Hedges and Greenwald (1996) survey the literature estimates for the U.S. The estimates for the public expenditure elasticity, μ, are between 0.10 (Card and Krueger, 1992) and zero. According to Betts (1996), the estimates of this parameter are larger the older the data set used. One interpretation is that education expenditures were more effective when average income was lower; i.e., earlier in the development path. Given the absence of systematic estimates for the Latin American countries or developing countries, $\mu = 0.10$ is used in the benchmark.

The model exhibits increasing returns to scale to augmentable factors in the production function for final goods and services. In order to avoid exploding growth rates, the education production function must exhibit just the right degree of decreasing returns. Hence, $\nu = 0.842$ is calibrated to generate a balanced growth path. Baier, Bergstrand and Glomm (2003) impose a similar "knife-edge" condition.

Concerning the goods production function, private physical capital's share of income, α, has been estimated at 0.60 for these seven Latin American countries by Elias (1992). The discount factor β is set to 0.40 using Rios-Rull's (1996) calibration of an overlapping-generations model.[6] Finally, the shift parameters A and B are set to 6.15 and 2.0 to yield a per capita growth rate of 1.30% per year for Period 1 and an end-of-period GDP per capita of $4,162 as the data in Table 1 indicates.

[6] Rios-Rull's (1996) estimate of 0.97 for β uses yearly frequency. In our setting, that translates to $(0.97)^{30} = 0.40$ since our unit of time is a 30-year generation.

4 Results

A benchmark solution to the model using the parameters described above is first calibrated. Then, policy experiments changing government expenditures are computed. The effects are presented and discussed below.

4.1 Changing Productive Public Expenditures

4.1.1 Education

Table 3 presents the results of reducing or raising public spending in education. Reductions of -1%, -2% are presented as well as increases of 1%, 2%, 3%, and 4% of GDP, all with respect to the benchmark expenditure of 2.9% of GDP. Note that results for 4 periods are presented. As observed in the data, the benchmark generates a per capita GDP growth rate of 1.30% per year and a income level of $4,162 at the end of Period 1 (i.e., 1970-1999).

Table 3
Public Expenditures on Education Effects

		Period			
		1	2	3	4
-2%	Growth	0.88	0.88	0.88	0.88
	Income	3,677	4,787	6,231	8,111
-1%	Growth	1.15	1.15	1.15	1.15
	Income	3,982	5,613	7,912	11,152
Benchmark	Growth	1.30	1.30	1.30	1.30
	Income	4,162	6,134	9,037	13,314
1%	Growth	1.40	1.40	1.40	1.40
	Income	4,292	6,520	9,904	15,044
2%	Growth	1.48	1.48	1.48	1.48
	Income	4,392	6,829	10,617	16,504
3%	Growth	1.54	1.54	1.54	1.54
	Income	4,474	7,087	11,223	17,772
4%	Growth	1.60	1.60	1.60	1.60
	Income	4,544	7,307	11,751	18,897

Growth: Average yearly per capita growth rate.
Income: Per capita income in U.S. $ at the end of the period.

Now, suppose that at the beginning of Period 1, the government had raised education expenditures by 2% of GDP above the benchmark. Such increase would put *total* education expenditure at about 5% of GDP, on par with the industrial countries of OECD and the U.S.A. As Table 3 shows, the resulting average growth rate would have then been 1.48%. This is an increase in 0.18 percentage points (1.48 - 1.30) in the per person growth rate. Growth is compounded over a 30-year generation, so income per person at the end of the generation would have been $4,392, or about 6% higher than it actually was in 1999 ($4,162). Hence, the additional education spending would have raised human capital levels, productive capacity, and income per person.

Subsequent generations (2, 3, and 4) also experience an increase in the per capita growth rate of about 0.18 percentage points. Given compounding, income per capita would have increased by about 11% for Generation 2 ($6,829 vs. $6,134) and by as much as 24% for Generation 4 ($16,504 vs $13,314). Consequently, spending more on education today has large effects on income of future generations.

It is also interesting to study the effects of reducing education expenditures. For instance, a 1% of GDP reduction leads to a fall in growth from 1.30% to 1.15%. An additional reduction of 1% of GDP, leads to a fall in the growth rate to 0.88%. By period 4, such reduction translates in per capita income of only $8,111 which is almost 40% lower than the benchmark level for that period of $13,314! Neglecting education can have sizable adverse effects on future generations.

4.1.2 Public Capital

Table 4 reports the effects of changing public investment in capital in a similar fashion as above. Consider, for comparison, a 2% of GDP raise in public investment. Results in Table 4 show that this would have yielded a 1.34% per capita growth rate for Generation 1. That is, growth would have risen by only 0.04 percentage points with respect to the benchmark. In comparison, the growth effect of a same-size raise in public education discussed in the previous sub-section would have been 4 times larger (0.18/0.04).

Table 4
Public Capital Expenditures Effects

		Period			
		1	2	3	4
-2%	Growth	1.24	1.24	1.24	1.24
	Income	4,090	5,922	8,573	12,411
-1%	Growth	1.27	1.27	1.27	1.27
	Income	4,130	6,037	8,824	12,897
Benchmark	Growth	1.30	1.30	1.30	1.30
	Income	4,162	6,134	9,037	13,314
1%	Growth	1.32	1.32	1.32	1.32
	Income	4,191	6,217	9,221	13,667
2%	Growth	1.34	1.34	1.34	1.34
	Income	4,215	6,289	9,382	13,995
3%	Growth	1.36	1.36	1.36	1.36
	Income	4,236	6,352	9,523	14,277
4%	Growth	1.37	1.37	1.37	1.37
	Income	4,255	6,407	9,649	14,529

Growth: Average yearly per capita growth rate.
Income: Per capita income in U.S. $ at the end of the period.

In terms of income per capita, the 2% of GDP raise in public investment would have raised it to $4,215 for Generation 1 and $13,995 for Generation 4. Comparing these to the benchmark levels, the increase in per capita income is about 1 to 5%, which is smaller than that resulting from education expenditure raises. Reductions in public capital (-1%, -2%) decrease growth and income, but these effects are not as large as those for education.

4.1.3 Robustness Checks

The key component of this paper is its quantitative evaluation of policy changes, so parameter choices are important. Hence, the parameters associated with public expenditures, θ and μ, are changed within the range estimated in the literature, and the results of policy changes are re-computed in order to explore how the results are affected. Recall that in the benchmark $\theta = 0.15$ and $\mu = 0.10$.

Two extreme cases are considered: 1) setting the parameters to their highest value ("Largest Scenario"), and 2) setting the parameters to their lowest value ("Smallest Scenario"). In the "Largest Scenario, " the elasticity of public capital θ is set to 0.20 following the larger cross country estimates from Fay (2001) and Canning and Fay (1993). The elasticity of education expenditures in human capital production μ is set to 0.15 following Betts (1996). In the "Smallest Scenario, " θ is set to 0.10 and μ is set to 0.05.[7] Table 5 and 6 report the results for each case respectively. In the "Largest Scenario," per capita growth is found to increase about 0.23 percentage points in every generation following a 2% of GDP raise in education expenditures (see Table 5). In the "Smallest Scenario" (Table 6), an equal size raise yields a 0.10 percentage point growth increase. Compare these two extreme cases with the baseline case (Table 3) which yielded a 0.18 percentage point increase.[8]

The public capital spending effects for the two extreme scenarios are also computed. In response to the 2% of GDP raise, growth rises by 0.10 (Largest Scenario) and 0.01 (Smallest Scenario). As found previously, these effects are still smaller than those resulting from public education spending increases.

[7] Recall, ν, the coefficient of lagged human capital, is calibrated to generate a balanced growth path. It is set to 0.7065 in the "Largest Scenario" and 0.9336 in the "Smallest Scenario."

[8] Robustness checks to the choice of congestion parameters were also conducted. Recall the congestion parameters were set in the benchmark to 0.015 to generate an effective public capital that was only 80% of the raw capital stock as suggested by an estimate in the 1994 World Development Report. Alternative values to generate reasonable congestion levels of 70% and 90% were tried. The impacts of policy changes were found to be not significantly different from the ones presented on Tables 3 and 4. Growth rates only typically differed in the third decimal place. Hence, the results are not presented but are available from the author.

Table 5
Public Expenditure Effects (Largest Scenario)

		Period			
		1	2	3	4
		Education Effects			
-2%	Growth	0.77	0.77	0.77	0.77
	Income	3,554	4,470	5,623	7,074
-1%	Growth	1.11	1.11	1.11	1.11
	Income	3,935	5,480	7,632	10,628
Benchmark	Growth	1.30	1.30	1.30	1.30
	Income	4,162	6,134	9,037	13,314
1%	Growth	1.43	1.43	1.43	1.43
	Income	4,327	6,627	10,150	15,546
2%	Growth	1.53	1.53	1.53	1.53
	Income	4,445	7,026	11,079	17,470
3%	Growth	1.61	1.61	1.61	1.61
	Income	4,560	7,360	11,879	19,172
4%	Growth	1.67	1.67	1.67	1.67
	Income	4,648	7,647	12,581	20,698
		Public Capital Effects			
-2%	Growth	1.17	1.17	1.17	1.17
	Income	4,004	5,674	8,040	11,394
-1%	Growth	1.24	1.24	1.24	1.24
	Income	4,090	5,920	8,570	12,406
Benchmark	Growth	1.30	1.30	1.30	1.30
	Income	4,162	6,134	9,037	13,314
1%	Growth	1.35	1.35	1.35	1.35
	Income	4,226	6,322	9,457	14,146
2%	Growth	1.40	1.40	1.40	1.40
	Income	4,282	6,489	9,835	14,905
3%	Growth	1.43	1.43	1.43	1.43
	Income	4,331	6,640	10,179	15,603
4%	Growth	1.47	1.47	1.47	1.47
	Income	4,375	6,775	10,492	16,248

Table 6
Public Expenditure Effects (Smallest Scenario)

		Period			
		1	2	3	4
		Education Effects			
-2%	Growth	1.08	1.08	1.08	1.08
	Income	3,897	5,377	7,419	10,236
-1%	Growth	1.22	1.22	1.22	1.22
	Income	4,065	5,851	8,420	12,118
Benchmark	Growth	1.30	1.30	1.30	1.30
	Income	4,162	6,134	9,037	13,314
1%	Growth	1.36	1.36	1.36	1.36
	Income	4,231	6,336	9,490	14,212
2%	Growth	1.40	1.40	1.40	1.40
	Income	4,284	6,495	9,849	14,933
3%	Growth	1.43	1.43	1.43	1.43
	Income	4,326	6,626	10,147	15,539
4%	Growth	1.46	1.46	1.46	1.46
	Income	4,362	6,736	10,401	16,061
		Public Capital Effects			
-2%	Growth	1.28	1.28	1.28	1.28
	Income	4,143	6,076	8,910	13,066
-1%	Growth	1.29	1.29	1.29	1.29
	Income	4,154	6,107	8,980	13,203
Benchmark	Growth	1.30	1.30	1.30	1.30
	Income	4,162	6,134	9,037	13,314
1%	Growth	1.31	1.31	1.31	1.31
	Income	4,170	6,155	9,085	13,409
2%	Growth	1.31	1.31	1.31	1.31
	Income	4,176	6,173	9,125	13,487
3%	Growth	1.32	1.32	1.32	1.32
	Income	4,181	6,188	9,158	13,554
4%	Growth	1.32	1.32	1.32	1.32
	Income	4,185	6,201	9,187	13,611

4.2 Expenditure Shifts

We have so far analyzed the effects of *raising* productive public expenditures. This sub-section describes the effects of *shifting* expenditures from education to public capital and vice versa without increasing the overall expenditure level.

Table 7 describes the effects of shifting expenditures from public capital to education. Notice that growth rates (and income levels) gradually rise until we shift 3% of GDP from education to infrastructure. At this point, the per capita growth rate is 1.44%, which is a 0.14 percentage point increase over the benchmark. Such redistribution amounts to a country spending about 6% of GDP on education $(2.9\% + 3\%)$ and about 4% of GDP $(7.27\% - 3\%)$ on infrastructure. Additional re-distributions in favor of education after 4% result in lower growth rates and income levels as Table 7 shows.

Table 7
Public Capital to Education Shifts

		Period			
		1	2	3	4
Benchmark	Growth	1.30	1.30	1.30	1.30
	Income	4,162	6,134	9,037	13,314
1%	Growth	1.38	1.38	1.38	1.38
	Income	4,258	6,417	9,671	14,575
2%	Growth	1.42	1.42	1.42	1.42
	Income	4,316	6,594	10,074	15,389
3%	Growth	1.44	1.44	1.44	1.44
	Income	4,345	6,682	10,277	15,803
4%	Growth	1.44	1.44	1.44	1.44
	Income	4,344	6,681	10,273	15,796
5%	Growth	1.42	1.42	1.42	1.42
	Income	4,307	6,567	10,001	15,261
6%	Growth	1.33	1.33	1.33	1.33
	Income	4,205	6,260	9,318	13,870

What are the effects of, on the other hand, shifting expenditures from education to infrastructure. Table 8 shows that such shifts would *decrease* growth rates. For example, shifting 1% of GDP from education to infrastructure would result in a net decrease of 0.13 percentage points and a fall in income per capita.[9]

Table 8
Education to Public Capital Shifts

		Period			
		1	2	3	4
Benchmark	Growth	1.30	1.30	1.30	1.30
	Income	4,162	6,134	9,037	13,314
1%	Growth	1.17	1.17	1.17	1.17
	Income	4,009	5,689	8,074	11,456
2%	Growth	0.93	0.93	0.93	0.93
	Income	3,724	4,909	6,471	8,529

5 Conclusion

This paper studies productive public expenditures in a quantitative-theoretic framework. An overlapping generations model is calibrated to seven Latin American countries. Higher public education expenditures are found to increase yearly growth rates by about 0.10 percentage points for every 1%-of-GDP increase (see Table 3). Given the power of compounding, such growth increases can lead to large income per capita increases for subsequent generations. The effects of raising education expenditures are found to be about four times larger than those from raising public capital. What is the reason for this? One possibility is that these seven Latin American countries have on average only spent about 3% of GDP on education while spending about 7% of GDP on public investment over 1970-99. That is, public capital has been overemphasized at the expense of education. Hence, the potential payoffs to raising human capital levels by raising education expenditures are larger.

This paper further finds that, even without raising additional funds, shifting expenditures from public capital to education can increase growth rates. Such re-distribution of up to 3 to 4% of GDP yield the maximum gains in

[9]Shifts of only up to 2% are reported on Table 8 as the benchmark expenditure is 2.9% of GDP, so it is not feasible to go much past this point.

growth. That is, while these seven countries appear to have neglected education expenditures, there is a limit to the positive effects of re-allocations. Too much shifting of resources towards education may in fact reduce growth rates as the public capital sector suffers.

Some caveats to the results should also be discussed. First, in practice there may exist rigidities to changing public expenditures in a country. For example, countries may have binding institutional constraints on the budget allocation (Feng, Kugler, and Zak, 2000; Ghate and Zak, 2002). Funds for the maintenance of roads, for instance, used to be typically raised by earmarking certain level of tax revenues specifically for this purpose. Hence, re-distribution from roads to education would not have been possible. Given the undesirable effects of earmarking, international organizations have lately discouraged countries from keeping this practice (Martinez-Vazquez and Xu, 2001).

Second, an influential book by Easterly (2001) finds that many "key-to-growth" policies have not had the desired effects. Easterly points out that if the incentives to growth are not present, raising education levels will have little effect. For example, policies that lead to high foreign exchange black market premiums provide incentives for rent-seeking and redistribution, so investing in education can be of little value to individuals. It must be acknowledged that the framework used in this paper abstracts from such considerations. Consequently, the results should be qualified as those resulting in an environment with minimal such distortions. On the other hand, Easterly also states that no country with low levels of education has become rich. Therefore, one can think of public expenditures on education and public capital as expenditures on the foundation for growth.

Colophon

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