Debt and Taxes: Financing Productive Government Expenditures

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Abstract

Government spending on public infrastructure, education and healthcare can provide a positive boost to economic growth. This paper finds that the appropriate financing of productive government spending depends on a country's fiscal position. Hence, the impact of additional public investment depends on both: how it is financed and on the existing levels of debt and various taxes. We develop a two-sector endogenous growth model to explore how variations in the composition and financing of government expenditures affect long-run economic growth. We find that, when tax rates are not already high, funding public investment by raising taxes may increase long-run growth. If existing tax rates are high, then public investment is only growth-enhancing if funded by restructuring the composition of overall public spending. We also find that additional public investment that is debt-financed can have adverse effects on long-run growth due to the resulting increases in interest rates and debt-servicing costs.

Keywords: productive government spending, economic growth, two-sector endogenous growth models, debt financing, Latin America.

JEL Codes: C63, H20, H50, H60, O41, O54

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1 Introduction

Government spending on public infrastructure, education and healthcare can provide a foundation for growth. Endogenous growth theory has shown that productive government spending can foster long-term economic growth. However, the appropriate strategy to fund such productive government spending may depend on the particular country's fiscal position. According to Easterly, Irwin, and Servén, (2007), "the appropriate fiscal strategy should be expected to vary across countries, depending on the volume of their revenues, the level and composition of their expenditures, their level of indebtedness, their endowments of public capital, their fiscal institutions, and a variety of other country-specific factors" (p.13). Hence, the economic impacts of, for example, additional investment on public infrastructure may not only depend on how that investment is funded, but also on the size of the existing debt of the country and the existing level of various taxes.

To explore the issues above, we develop a two-sector endogenous growth model in which public investment is divided between physical capital (infrastructure) and human capital (education and health). We use the model to analyze how public investment spending funded by taxes on income or consumption or by borrowing affects long-term output growth. In addition, we explore how existing fiscal conditions affect the impact of new public spending on growth. We use alternative parameterizations of the model to simulate extreme initial fiscal conditions such as high average tax rates, debt stock ratios and government consumption spending. We also examine the effect of varying the composition of public expenditures, shifting between consumption and investment spending, or re-allocating between different types of public investment.

Our main contribution is to explore how the state of a country's fiscal situation affects the impact of new public investment. It is motivated by Easterly, Irwin, and Servén (2007, 2008) who study how fiscal adjustment in Latin America in the last 20 years has been done at the expense of reducing public investment.[1] They find that the long-term adverse consequences

[1] In the 1980s and 1990s, the region engaged in a wave of fiscal adjustment initiatives aimed at scaling

of such adjustments can outweigh the potential benefits of short-term budget tightening. This will in particular depend on the country's fiscal situation.

The model is calibrated to reflect economic conditions in the seven largest Latin American economies during the period 1990 to 2008. These Latin American countries provide a suitable testing ground for the implications of the model given their debt history and diverse fiscal adjustment experiences. We find that, when tax rates are not already high, funding public investment by raising taxes may increase long-run growth. If existing tax rates are high, then public investment is only growth-enhancing if funded by restructuring the composition of public spending. We also find that additional public investment that is debt-financed can have adverse effects on long-run growth since the resulting increases in interest rates and debt-servicing costs crowd out the positive effects of public investment.

Our paper is related to several strands in the literature. First, it is related to the literature of productive public expenditures in endogenous growth models which includes Barro (1990), Glomm and Ravikumar (1994, 1997), and Rioja (1999) among others.[2] In particular, we extend an endogenous growth model similar to Futagami, Morita, and Shibata (1993) and Greiner and Semmler (2000) by distinguishing between different types of public capital. Second, the paper is related to the literature on the composition of public expenditures and growth. This literature includes Turnovsky and Fisher (1995), Feltenstein and Ha (1995), Devarajan, Swaroop, and Zou (1996), Agénor and Neanidis (2006), among others. Turnovsky and Fisher (1995) study how the composition between government consumption and infrastructure expenditure affect the economy. Feltenstein and Ha (1995) demonstrate that public infrastructure spending has diverse productivities in different sectors. Devarajan, Swaroop, and Zou (1996) show that the growth-maximizing allocation of public expenditure is achieved by equating the ratio of output elasticities with the ratio of initial spending

back government activity, increasing revenue generation and bringing debt to sustainable levels (Calderón and Servén, 2004; Easterly, Irwin, and Servén, 2008). Declines in fiscal deficits seemed to be largely driven by cuts in public investment. It is estimated that in the five largest economies, infrastructure investment cuts alone contributed at least half of the total fiscal adjustments (Calderón, Easterly, and Servén, 2003a,b).

[2]There is also a large empirical literature on the growth effects of public infrastructure summarized in Ligthart and Martin Suarez (2011).

shares. Agénor and Neanidis (2006) study the optimal allocation of government spending among health, education and infrastructure, taking into account complementarities among the three sectors. Our model builds on this body of work, explicitly recognizing the inherent complementarities and tradeoffs among different types of productive government expenditures.

A third strand of related literature is the work on the various ways of financing public expenditures. Turnovsky (1996) uses consumption and income taxes and debt, finding that the optimal mix of financing depends on the level of infrastructure with respect to the social optimum and the degree of congestion. Greiner and Semmler (2000) model debt as a stock and account for feedback effects of debt servicing. They find that debt-financed public investment can promote economic growth, but only under certain conditions. Futagami, Iwaisako and Ohdoi (2008) study the growth effects of various financing schemes in a multiple equilibrium model. Assuming that the debt-to-GDP ratio must not exceed a certain threshold, they show that borrowing may raise or lower growth depending on a high or low steady-state level. Chatterjee and Turnovsky (2005, 2007) use a small open economy model to explore the effect of financing public investment with foreign aid. Their results show that the effect on long-run growth varies depending on whether the aid is specifically tied to investment activity or not. In addition, they find that key structural characteristics of the recipient country matter in determining the extent of the effect.[3] Our work extends this literature by showing that the optimal strategy to finance public investment will also depend on the existing fiscal conditions of the economy.

The rest of the paper is organized as follows. Section 2 presents the theoretical model. Section 3 describes the solution and calibration procedure, while section 4 discusses the results of various policy experiments. Section 5 concludes.

[3] The structural characteristics include relative installation costs of public versus private capital; degree of access to global financial markets; substitutability of public and private capital in production; and flexibility of the labor supply (Chatterjee and Turnovsky, 2005).

2 The Theoretical Model

We extend the theoretical models developed by Futagami, Morita, and Shibata (1993) and Greiner and Semmler (2000) to determine how the composition and financing of public expenditure affect long-term economic growth. This model is appealing because it moves away from the balanced government budget assumption typical of the fiscal policy and growth literature and allows governments to use bond-financing in addition to taxes, as long as long-term debt sustainability is maintained. Such a formulation more realistically captures the financing practices of the Latin American economies under study. We extend the Greiner-Semmler model by distinguishing between different types of public capital, allowing for heterogeneity in their output elasticities. This is done within the context of a two-sector endogenous growth model in which intermediary human capital and a final market good are produced. The government is assumed to supply public capital complementary to the production process in either sector. In contrast to previous models that work with expenditure flows (Agénor & Yilmaz, 2011; Agénor & Neanidis, 2006), we follow the tradition of Futagami et al. (1993), Greiner (2008) and Turnovsky (2004) by developing a model with stocks. All variables are in per capita form and we define public capital as non-excludable but subject to congestion. The model is later calibrated to represent the seven largest economies in Latin America.

2.1 Households

The economy is inhabited by infinitely-lived identical households who supply labor, L, inelastically. To simplify the model, we abstract from population growth and normalize the number of households to unity. The representative household derives utility from private consumption, $C(t)$, and preferences are given by the inter-temporal iso-elastic utility function

$$U(C) = \int_0^\infty e^{-\rho t} \left(\frac{C^{1-\sigma} - 1}{1-\sigma} \right) dt, \qquad \sigma \neq 1, \tag{1}$$

where the time argument has been suppressed.[4] $\rho \in (0,1)$ denotes the pure rate of time preference and σ is the inverse of the inter-temporal elasticity of substitution in consumption.[5] A household's effective labor, HL, is its human capital (H) times the number of hours the household works, L. A share u ($0 < u < 1$) of this effective labor is employed in the production of final goods and services. Hence the household earns wage income in the final goods market equal to $wuHL$, where w is the wage rate. Household income also comes from returns to wealth, $W \equiv B + K$, which is equal to public debt, B, and private physical capital, K. Income is spent on private consumption and new investments in physical capital, $\dot{K}$, and government bonds, $\dot{B}$, where the dot gives the derivative with respect to time. The government levies flat rate taxes, τ_K and τ_L, on income earned from capital and labor, respectively. There is also an *ad valorem* tax, τ_C, on private consumption. Normalizing labor to one, the representative household's budget identity is thus written as

$$(1+\tau_C)\,C + \dot{W} + \delta_K K = (1-\tau_L)\,wuH + (1-\tau_K)\,(rK + r_B B)\,, \tag{2}$$

where $\delta_K \in (0,1)$ is the depreciation rate of physical capital, w denotes the real wage rate, r is the real return to physical capital and r_B is the interest rate on government bonds. A no-arbitrage condition requires that the return to physical capital equals the return to government bonds yielding $r_B = r - \delta_K/(1-\tau_K)$.[6] Thus, the budget identity of the household can be re-written as

$$\dot{W} = (1-\tau_L)\,wuH + (1-\tau_K)\,rW - \delta_K W - (1+\tau_C)\,C. \tag{2a}$$

[4] This specification is widely accepted in the literature with variants used by Barro (1990), Bruce and Turnovsky (1999) and Corsetti and Roubini (1996). For ease of exposition, we omit the time argument t, unless doing so would cause ambiguity.

[5] For $\sigma = 1$ the utility function is replaced by the logarithmic function $U(\cdot) = \ln C$.

[6] Since both are taxed at rate τ_K, it follows that $(1-\tau_K)\,r_B = (1-\tau_K)\,r - \delta_K$, which implies that $r_B = r - \delta_K/(1-\tau_K)$.

To allow the analysis to be more tractable, we abstract from depreciation (i.e., set $\delta_K = 0$) so that the household's budget constraint is more simply written as

$$\dot{W} = (1 - \tau_L)\, wuH + (1 - \tau_K)\, rW - (1 + \tau_C)\, C. \tag{2b}$$

The problem for the representative household is to maximize the discounted stream of utility, defined in (1), over an infinite time horizon subject to its budget constraint in (2b), taking factor prices as given. The current-value Hamiltonian is

$$J = \frac{C^{1-\sigma} - 1}{1 - \sigma} + \lambda \left[(1 - \tau_L)\, wuH + (1 - \tau_K)\, rW - (1 + \tau_C)\, C \right], \tag{3}$$

where λ is the co-state variable for the shadow price of wealth.

By dynamic optimization, the necessary optimality conditions are obtained as:

$$C^{-\sigma} = \lambda\, (1 + \tau_C)\,, \tag{4}$$

$$\dot{\lambda} = \lambda\rho - \lambda\, (1 - \tau_K)\, r. \tag{5}$$

Equation (4) equates the marginal utility of consumption to the individual's tax-adjusted shadow value of wealth, while (5) is the standard Keynes-Ramsey consumption rule, equating the rate of return on consumption to the after-tax rate of return on capital. If the transversality condition $\lim_{t\to\infty} e^{-\rho t}\lambda W = 0$ holds, which is fulfilled for a time path on which assets grow at the same rate as consumption, the necessary conditions are also sufficient.

2.2 Producers

The economy is assumed to have two sectors, producing two kinds of goods: a final private market good and intermediary human capital – a portion of the latter being used in the production of the former. While public capital is assumed complementary to the production of both goods, we distinguish between the types of public capital that enter each stage of the process. To this end, productive government spending is divided into investment in core public infrastructure assets (such as transport and communications systems, energy, water supply and sanitation) and public investment to enhance education and health services that increase the stock of human capital. As noted by Semmler et al. (2011), decomposing the productive capacity of public capital in this way more realistically captures the longer gestation lag in creating human capital relative to typical physical infrastructure. Even more important for the purposes of this paper, the decomposition allows us to isolate the effects of different kinds of government spending.

2.2.1 Market good

Production of market goods, Y, is carried out by many identical firms which can be represented by one firm which behaves competitively and which maximizes static profits. The production function is given by a Cobb-Douglas technology[7]

$$Y = AK^{1-\alpha-\beta} (uH)^{\alpha} (vK_G)^{\beta}, \tag{6}$$

where A is a productivity parameter and K_G represents the stock of public capital. $u, v \in (0, 1)$ represent the respective shares of human capital and public capital used in the production of market goods. The remaining portions are used to build human capital and thus influence production indirectly. $\alpha, \beta \in (0, 1)$ denote output elasticities so that production displays constant returns to scale in all factors together.

2.2.2 Human capital accumulation

Human capital production can be thought of as a non-market, tax-free activity (Mendoza, Milesi-Ferretti, & Asea, 1997), which uses a Cobb-Douglas technology similar to the final

[7] The Cobb-Douglas functional form has been criticized for its restrictiveness. It imposes a unitary elasticity of substitution between factors of production which does not hold up in reality. Nevertheless, the Cobb-Douglas production function is widely used in theoretical models precisely because of this mathematical simplification which makes it more analytically tractable. For a discussion of more flexible production forms see Bom, Heijdra and Ligthart (2010), who present the constant elasticity of substitution case.

market good such that

$$\dot{H} = Q\left[(1-u)H\right]^{1-\varepsilon}\left[(1-v)K_G\right]^{\varepsilon}, \tag{7}$$

where Q is the productivity parameter and $\varepsilon \in (0,1)$ represents the elasticity of the production of human capital with respect to public capital stock in education and health facilities. Thus, the technology is again assumed to have constant returns to scale in all factors together. Similar representations for human capital formation have been used by Agénor and Neanidis (2006), Bayraktar and Pinto Moreira (2007), and Monteiro and Turnovsky (2008). The share of public capital stock employed in private production, v, can be used as a policy variable to analyze how variations in the allocation of productive government spending affect growth.

Assuming competitive markets, it must hold that the cost of capital, r, and the wage rate, w, are equal to their marginal products, respectively. This gives

$$w = \alpha\left(uH\right)^{-1}Y, \tag{8}$$

$$r = (1-\alpha-\beta)K^{-1}Y. \tag{9}$$

2.3 The Government

The government in this economy has a range of financing options and is not constrained to run a balanced budget in each period. However, it must repay all its debt at the end of time, such that $\lim_{t\to\infty} B(t)\exp\left(-\int_0^t (1-\tau_K)(r(s))\,ds\right) = 0$, must hold. That is, the government is not allowed to run a Ponzi game; discounted debt converges to zero asymptotically. The government receives tax revenues from income and consumption taxes and can raise additional revenues from issuing government bonds. Note that Ricardian equivalence fails due to the presence of distortionary income taxes. Government expenditure is split between public consumption, C_p, investment in public capital, I_p, and (net) debt servicing, rB.

The accounting identity describing the accumulation of public debt in continuous time is given by:

$$\dot{B} = rB + C_p + I_p - T, \tag{10}$$

where T denotes total tax revenue such that $T = \tau_L wuH + \tau_K rK + \tau_K rB + \tau_C C$. Public consumption[8] expenditure is assumed not to affect productivity, but has to be financed through taxes and constitutes a certain share of tax revenue, $C_p = a_1 T$, $0 < a_1 < 1$. The government is allowed to borrow to finance productive expenditures which will yield returns in the future, but must finance public consumption expenditures and interest payments from current tax revenue so that $C_p + rB = b_1 T$, $0 < b_1 < 1$. This formulation approximates the golden rule of public finance – a fiscal rule that allows the government to borrow only for investment but not to fund current spending (Buiter, 2001).[9] The remaining tax share allotted to public investment would thus be $I_p = b_2 (1 - b_1) T$, where $b_2 > 1$ implies debt financing. Variations in the fiscal policy parameter b_2 allow us to explore the effect of debt financing on growth. Rewriting (10), the accumulation of public debt becomes

$$\dot{B} = T (1 - b_1) (b_2 - 1), \tag{10a}$$

where T is as defined above.

Ignoring depreciation, the differential equation describing the evolution of public capital may therefore be written as

$$\dot{K}_G = I_p = b_2 (1 - b_1) T. \tag{11}$$

[8]Here public consumption refers to social transfers and expenditure with public goods characteristics, which do not affect production but may enter into household preferences (such as public parks, civic facilities and consumption transfers).

[9]The original conceptualization of the golden rule makes a distinction between current and capital expenditures. Here, we make the distinction between unproductive and productive expenditures broadly defined, so that the latter may include recurrent expenditures that contribute to the stock of human capital, such as spending on education and health, and so may be considered productive.

2.4 Equilibrium Conditions and the Balanced Growth Path

2.4.1 Equilibrium conditions

An equilibrium allocation for this economy is defined as a sequence of variables $\{C(t), K(t), H(t), K_G(t), B(t)\}_{t=0}^{\infty}$ and a sequence of factor prices $\{w(t), r(t)\}_{t=0}^{\infty}$ such that, given prices and fiscal parameters, the firm maximizes profits, the household solves (1) subject to (2b) and the budget identity of the government (10a) is fulfilled.

Using (4), (5), (6) and (9), which must hold in equilibrium, equation (4) can be rewritten as

$$C = (\lambda(1+\tau_C))^{-\frac{1}{\sigma}}.$$

Taking logs of this expression and differentiating with respect to time yields the growth rate of consumption

$$\frac{\dot{C}}{C} = \frac{1}{\sigma}\left((1-\tau_K)(1-\alpha-\beta) A K^{-\alpha-\beta}(uH)^{\alpha}(vK_G)^{\beta} - \rho\right), \tag{12}$$

which is equal to the growth rate of the economy, γ, in steady-state. For the evolution of private capital, we combine the definition of $\dot{B}$ in (10) with the individual consumer's budget constraint given in (2b) to obtain

$$\frac{\dot{K}}{K} = (1-\beta)\frac{Y}{K} - \frac{C}{K} - (a_1 + b_2(1-b_1))\frac{T}{K}. \tag{13}$$

Thus, in equilibrium the economy is completely described by (7), (10a), (11), (12) and (13) plus the limiting transversality condition of the household.

2.4.2 The balanced growth path

We restrict the analysis to the steady-state where we assume that all the variables in the economy grow at their long-run growth rate. For our purposes, we define a balanced growth path (BGP) as a path such that the economy is in equilibrium and such that consumption, private physical capital, human capital, public capital and government debt grow at the same strictly positive constant growth rate; that is, $\frac{\dot{C}}{C} = \frac{\dot{K}}{K} = \frac{\dot{H}}{H} = \frac{\dot{K}_G}{K_G} = \frac{\dot{B}}{B} = \gamma$, $\gamma > 0$ and is constant. To analyze the model around the BGP we define the new variables $c \equiv C/K$, $h \equiv H/K$, $g \equiv K_G/K$, $b \equiv B/K$. Differentiating these variables with respect to time leads to a four-dimensional system of differential equations given by

$$\begin{aligned}
\frac{\dot{c}}{c} &= \frac{\dot{C}}{C} - \frac{\dot{K}}{K} = 0, \\
\frac{\dot{h}}{h} &= \frac{\dot{H}}{H} - \frac{\dot{K}}{K} = 0, \\
\frac{\dot{b}}{b} &= \frac{\dot{B}}{B} - \frac{\dot{K}}{K} = 0, \\
\frac{\dot{g}}{g} &= \frac{\dot{K}_G}{K_G} - \frac{\dot{K}}{K} = 0,
\end{aligned} \tag{14}$$

where

$$\begin{aligned}
\frac{\dot{C}}{C} &= \frac{1}{\sigma}\left((1-\tau_K)(1-\alpha-\beta)\frac{Y}{K} - \rho\right), \\
\frac{\dot{H}}{H} &= Q(1-u)^{1-\varepsilon}(1-v)^{\varepsilon}\left(\frac{H}{K}\right)^{-\varepsilon}\left(\frac{K_G}{K}\right)^{\varepsilon}, \\
\frac{\dot{B}}{B} &= \frac{T}{B}(1-b_1)(b_2-1), \\
\frac{\dot{K}_G}{K_G} &= \frac{T}{K_G}(1-b_1)\,b_2 \text{ and} \\
\frac{\dot{K}}{K} &= \left[(1-\beta) + (1-\alpha-\beta)\frac{B}{K}\right]\frac{Y}{K} - \frac{T}{K}\left(1+(1-b_1)(b_2-1)\right) - \frac{C}{K},
\end{aligned} \tag{15}$$

with $\frac{Y}{K} = A\left(u\frac{H}{K}\right)^{\alpha}\left(v\frac{K_G}{K}\right)^{\beta}$, $\frac{T}{K} = \tau_L\alpha\frac{Y}{K} + \tau_K\left(1+\frac{B}{K}\right)(1-\alpha-\beta)\frac{Y}{K} + \tau_C\frac{C}{K}$ and $b_1 = a_1 + (1-\alpha-\beta)\frac{Y}{K}\frac{B}{T}$.

A solution $\dot{c} = \dot{h} = \dot{g} = \dot{b}$ with respect to c, h, g, b gives a balanced growth path for the model and corresponding ratios c^*, h^*, g^*, b^* on the balanced growth path. The high dimension of the dynamic system makes it analytically intractable. We therefore rely on numerical simulations to establish the existence and stability of the steady-state equilibrium.

3 Model Calibration and Solution

The model is calibrated for the seven largest economies in Latin America to correspond to average economic performance during 1990-2008. Table 1 gives some selected economic data for these countries. Over the study period, the average annual growth rate of GDP per capita was 2.3 percent. The average size of government (as measured by government spending to GDP) was 20.8 percent. Of this, the greater share was spent on public consumption (12.7 percent of GDP), while 5.1 percent of GDP went to public investment. The remainder went to debt servicing and other expenses. Public spending was financed by revenue from taxation and other sources, as well as debt. On average, total revenue was about 21.3 percent of GDP, with tax revenue constituting the largest share.[10] The average stock of debt per country was 34.6 percent of GDP with Argentina, Brazil, Chile and Peru having debt stocks above the average. The benchmark parameters of the model are chosen to reflect these statistics.

Table 2 presents the values of parameters used in the benchmark model representing the average data for the region ("Region Average"). The rate of time preference, ρ, is set at a standard value of 0.04 which leads to a discount factor of approximately 0.96 that is in line with the literature (Bayraktar & Pinto Moreira, 2007; Rioja, 2005). We set the inverse of the intertemporal elasticity of substitution, σ, to 2. This value is lower than what is typi-

[10] Other sources of revenue include royalties from natural resource extraction which vary across countries according to the level of production in the mineral sector and the extent to which tax incentives are used to attract foreign investors (OECD, 2008).

cally used for industrial country studies and is consistent with evidence indicating that the intertemporal elasticity of substitution tends to be lower at low levels of income (Bayraktar & Pinto Moreira, 2007). The share of human capital employed in private production is set to 0.9, which is the average between values used by Bayraktar and Pinto Moreira (2007) for Haiti and Semmler et al. (2011) for a set of middle- and low-income countries.

We set the elasticity of output with respect to public capital in infrastructure, β, to 0.15. This is close to the 0.138 estimated by Calderón and Servén (2003) for the elasticity of GDP to infrastructure for a group of countries in Latin America, as well as to the 0.147 estimate used by Suescun (2005) for Colombia. The value for the elasticity of output with respect to human capital, α, is put at 0.3 which is the average of the estimates used by Bayraktar and Pinto Moreira (2007), Rioja (2005) and Semmler et al. (2011). The constant returns to scale technology used in the model, thus, implies that the output elasticity of private capital is 0.55. This is larger than the 0.33 typically found in OECD countries, but close to the value of 0.60 estimated by Elias (1992) for the group of Latin American countries under study.

For the production of human capital, the elasticity of public capital stock in education and health, ε, is set at 0.30. This value is larger than the 0.10 used by Rioja (2005) and the econometric estimate obtained by Blankenau, Simpson and Tomljanovich (2007) for the elasticity of the public capital stock in education only. Since the model combines public capital in both education and health for human capital production, we use a higher value to take into account externalities from complementarities between the two forms of spending.[11] Our estimate is close to that used by Semmler et al. (2011).

Since a fraction of public capital is used to produce human capital – itself an input factor in private market production – the final output elasticity of total public capital is derived

[11] Agénor and Neanidis (2006) provide several examples of the interaction between health and education to improve the quality of human capital. Healthier students are more likely to participate and do better in school. Among the examples cited, Baldacci et al. (2008) show that health capital has a statistically significant effect on school enrollment rates. Simultaneously, the evidence shows that higher education levels can improve health. Smith and Haddad (2000) report that improvements in female secondary school enrollment rates during 1970-1995 accounted for 43 percent of the total reduction in the child underweight rate of developing countries.

from the model as $\varepsilon\alpha + \beta$. Given the selected parameters, the size of the output elasticity of total public capital is thus 0.24. This value is consistent with the 0.268 estimated by Bom and Ligthart (2009) in a meta-analysis on the output elasticity of public capital for a sample of 67 studies. The remaining parameters – the shift factors and fiscal policy variables – are set to achieve a baseline growth rate consistent with the data for the seven Latin American countries of interest.

The steady-state results of the numerical simulation are presented in the last column of Table 3. As is shown, the calibrated model provides a fair representation of the performance of the average Latin American economy over the last two decades. In particular, the steady-state growth rate, public debt and overall domestic investment correspond almost exactly with the actual regional averages over the study period. Other indicators, such as total revenue and public expenditure levels, are also very closely replicated in the model. We use these results as the benchmark for various fiscal policy experiments.

4 Policy Experiments

Given the importance of public investment to growth, we use numerical simulations to explore how variations in the composition and financing of public investment expenditure affect the steady-state growth rate. We conduct four types of fiscal policy experiments: (a) increase public investment financed by new debt issues, (b) increase public investment financed by raising taxes (income or consumption), (c) increase public investment by re-allocating spending away from public consumption, and (d) re-allocating public investment in infrastructure toward education and healthcare. We first examine the case for the average Latin American country and then examine how the growth effects vary when initial fiscal conditions are more extreme. Three scenarios are investigated: (a) when both the existing debt ratio and tax rates are high ("High Debt, High Tax" scenario); (b) when the debt ratio and tax rates are low ("Low Debt, Low Tax" scenario); and (c) when the debt ratio is high, but tax rates are low ("High Debt, Low Tax" scenario). [12]

4.1 Financing increased public investment by issuing new debt

Financing public investment through increased borrowing is detrimental to growth (see top panel of Table 4). As described in the model section, the parameter b_2 governs the size of the debt. When b_2 is increased from 2 to 2.5 causing debt to increase from 36.7 to 41 percent, the steady-state growth rate falls from 2.50 percent per year in the benchmark case to 2.36 percent. Increasing the debt in that proportion would be similar to going from a debt level as in Argentina to a debt level as in Brazil. The new borrowing has two effects: (a) It increases the debt stock ratio (B/Y), which then translates into higher debt repayments; and (b) It also raises interest rates (the marginal cost of borrowing) so that repayments are even larger. The higher debt-servicing costs (rB/Y) eventually crowd out spending on public investment (I_P/Y) so that, instead of increasing, the ratio of public investment to GDP actually falls from 4.59 to 4.17 percent in the steady state. The elevated interest rate will also discourage private investment causing an additional crowding-out effect.

The model shows that for countries already using deficit financing, and which have average debt stock ratios around 35 percent of GDP, such as Argentina, it is better to reduce the amount of deficit-financing being used. Reducing b_2 slightly to 1.9 (i.e., lowering the debt stock by about one percent of GDP) is shown to increase the growth rate by 0.04 percentage points. In this case, the share of public investment now actually increases by 0.12 percentage points to 4.71 percent of GDP, since debt repayments are reduced and more money is made available for investment. The implication is that the existing debt burden in Latin America may already be too high so that financing additional public investment by further increasing the debt stock may be counterproductive.

[12] A fourth possible case "Low Debt, High Tax" might also be of interest. However, simulating this scenario in the current model involves altering more than just the relevant policy variables; significant adjustments to the baseline parameters are also required. Such changes would substantially alter the underlying structure of the original simulated economy, limiting our ability to make cross-scenario comparisons. Therefore, only the first three scenarios are considered.

4.2 Financing increased public investment by raising taxes

4.2.1 Increasing tax rate on capital and labor income

Next we change the income tax rates for both capital and labor (τ_K and τ_L) in equal percent changes. Public investment financed by higher income taxes raises the steady-state growth rate (see middle panel of Table 4). The higher income tax rates increase the amount of tax revenue (T/Y) generated and thus enlarge the potential pool of funds available for public expenditure. A one-percentage-point change from 15 to 16 percent in the tax rate causes a corresponding rise in tax revenue to GDP (23.54 to 24.41 percent). This in turn increases public investment spending to 4.72 percent of GDP, which raises the public capital stock and subsequently the growth rate by 0.02 percentage points to 2.52 percent. Similar growth effects are experienced if the income tax rate is further increased to 17 percent.[13] Conversely, reducing the income tax rate reduces available funds for public investment and reduces the growth rate. For example, lowering the income tax rate to 13 percent causes the growth rate to fall by 5 percentage points to 2.45 percent.

4.2.2 Increasing tax rate on consumption taxes

We alternatively try to achieve an increase in tax revenue using the consumption rather than the income tax (see middle panel of Table 4). Raising the consumption tax rate from 20 to 21 percent increases the tax revenue relative to GDP to 23.96 percent, stimulating an increase in public investment spending to 4.67 percent and raising the growth rate to 2.53 percent. It is interesting to note that a one-percentage-point increase in the consumption tax rate generated slightly less revenue (relative to GDP) than a similar increase in the income tax rate, but had a greater effect on growth. This may be due to the less distortionary impact of consumption taxes on investment and saving decisions relative to the capital income tax,

[13] It must be noted that the tax increase is not exclusively spent on public investment; it is spread across consumption spending and debt repayment as well. This has to do with how the model is formulated, making public consumption spending and debt repayments positive linear functions of tax revenue. In practical terms, this can be interpreted as representing fungibility in the use of public funds (Erekson, DeShano, Platt, & Ziegert, 2002; Lago-Penas, 2006).

which reduces the net rate of return to private capital and thus causes disincentives to investment. Therefore, if the choice is between an increase in the income or the consumption tax, from the point of view of growth, a consumption tax would be preferred.[14] Again, it must be noted that taxes cannot be raised indefinitely and for values higher than $\tau_C = 0.22$ the model fails to arrive at a steady-state solution.

It must be stressed that the tax rates used in the simulations are chosen so as to replicate the average tax revenue as a share of GDP, and do not reflect actual tax rates in the Latin American economies. Marginal tax rates in these countries are, in fact, higher with top marginal rates for corporate and individual income taxes ranging between 35 and 40 percent. Tax theory tells us that the efficiency loss from a tax increases exponentially with the tax rate. Therefore, we may expect smaller improvements in the equilibrium growth rate if higher marginal tax rates are actually taken into account.

Further, the model abstracts from several things, including tax evasion. Our simplified representation assumes that increases in the tax rate translate fully into corresponding increases in tax revenue. However, the tax literature shows that as the marginal rate increases, we might expect to see greater incidence of tax evasion (Alm, 1999), so that later tax increases may not be as effective in generating additional revenue. This possibility weakens the case for funding additional public investment through raising tax rates.

4.3 Restructuring public spending

4.3.1 Re-allocating spending from public consumption to investment

Shifting expenditure away from public consumption toward public investment increases the steady-state growth rate (see bottom panel of Table 4). This finding is consistent with the consensus in the growth literature. However, doing quantitative analysis in a fully speci-

[14] There may be other factors to take into consideration such as the higher burden a consumption tax places on the poor (Vasquez, 1987). Nevertheless, because of high informality and difficulty in capturing the tax base, consumption taxes are used more predominantly in developing countries, including Latin America (Bird & Gendron, 2007).

fied general equilibrium macroeconomic model allows us to determine just how potentially stimulating even a slight restructuring of public expenditure can be. Lowering public consumption to GDP by about one percentage point (from 14.12 in the baseline scenario to 13.05; achieved by reducing a_1 to 0.55) increases public investment to 5.23 percent of GDP and increases the growth rate to 2.7 percent per year. Re-allocating an additional percent (lowering a_1 to 0.50) further increases the growth rate to 2.89 percent.

While it is obvious that a restructuring of public spending away from unproductive toward productive expenditure is growth-enhancing, such a policy may be politically difficult to implement. This is particularly true for Latin American countries where there has been a long history of populist governments (Conniff, 1999; Ronchi, 2007). This phenomenon would help explain why capital rather than current expenditures were disproportionately cut during the fiscal adjustment episodes. Given the difficult political challenge to cut consumption expenditures, it is necessary to explore alternative shifts in spending which may be more politically feasible.

4.3.2 Re-allocating between infrastructure and human capital spending

One advantage of the model is that it allows for heterogeneity among different forms of productive public expenditure. Shifting the emphasis of public investment away from infrastructure and towards public capital which more specifically supports human capital formation is growth-enhancing. Changing the allocation by just five percentage points ($v = 0.85$) increases the steady-state growth rate from 2.5 to 2.9 percent, the most significant increase of all the policy experiments. The higher growth rate comes about through the following channel: more spending in the human capital sector raises the ratio of human capital to private capital, h^*, from 0.123 in the benchmark case to 0.149. Human capital, being the limiting factor, has a higher marginal productivity so that any given increase generates more output than a similar increase in physical capital and thus stimulates the growth rate more. Further shifts in public investment spending ($v = 0.8$) that bring the human/private capital ratio to 0.171 cause the growth rate to increase to 3.19 percent.

We note that these results may be dependent on the specific parameter values assigned to the output elasticities for public capital spent on human capital accumulation and private market output, respectively. Robustness checks are therefore carried out with alternative parameters (within the purview of the literature) to see how results vary. Simulations for a range of values of ε show that the effects on growth are not qualitatively different from the baseline results (see Table A1 in the Appendix). Our findings are consistent with Rioja (2005) who explores similar shifts between infrastructure and education spending for the same group of countries; and Montiero and Turnovsky (2008) who calibrate a similar model for the United States. Re-allocating spending to the most productive uses will generate the best returns on public investment and give the strongest boost to growth. Productivity of the factor in relatively short supply is higher and public capital to boost this factor will have greater marginal returns.

4.4 Fiscal Strategy under Different Initial Fiscal Conditions

4.4.1 "High Debt, High Tax" scenario

Of the seven Latin American countries under study, the "High Debt, High Tax" scenario (henceforth abbreviated to HDHT) might represent Chile which has tax and debt ratios above average. The steady-state results for the HDHT scenario are presented in Table 5. The new benchmark from which policy experiments are simulated is achieved by increasing the tax and debt parameters as indicated at the bottom of the table. In the HDHT benchmark solution (presented in bold type), tax revenue to GDP (T/Y) is approximately 30 percent and the debt stock ratio (B/Y) is about 51 percent. The corresponding steady-state growth rate is 2.44 percent, which is lower than in the scenario representing the region average.

When the fiscal policy experiments are simulated, the results show that financing increased public investment by issuing new debt reduces growth, which is the same effect as in the average case. Increasing b_2 raises the debt ratio, lowers public investment to GDP and eventually lowers the steady-state growth rate.

Using higher income taxes to fund public investment clearly demonstrates a nonmonotonic relationship between the tax rate and growth in the HDHT case. Initially raising the income tax rate from 20 to 22 percent, and then 24 percent, increases public investment and stimulates a rise in the growth rate from 2.44 to 2.5 percent. However, further increasing the income tax rate beyond 24 percent has a deleterious effect on growth, which starts to fall even as the share of public investment to GDP continues to rise. The HDHT scenario clearly demonstrates the nonmonotonic growth effect when public spending is financed by distortionary taxes. This implies that when initial tax rates are already high, there is little room for further income tax rate increases to support the budget. On the other hand, increasing the consumption tax rate instead of the income tax rate shows no evidence of a nonmonotonic effect, but rather consistently increases growth.

The remaining policy experiments have qualitatively similar growth effects as in the region average case. Shifting spending from public consumption to investment is growth-enhancing, while re-allocating from public investment in infrastructure toward education and health also stimulates higher growth. Changing the allocation to infrastructure by just five percentage points (going from $v = 0.90$ to $v = 0.85$) increases the steady-state growth rate from 2.44 to 2.84 percent.

4.4.2 "Low Debt, Low Tax" scenario

In the "Low Debt, Low Tax" (LDLT) scenario, funding public investment by raising either income or consumption taxes has the potential for considerable improvement to growth. The steady-state results are shown in Table 6. The respective benchmark tax-to-GDP (T/Y) and debt-to-GDP (B/Y) ratios are 17.8 and 29.86 percent, respectively, which roughly approximates the fiscal situation in Mexico during the study period. The results demonstrate that when tax rates are initially low, there is room for substantial increases before the negative financing effects outweigh the positive impact of public investment. In the simulations, increasing income tax rates from 13 to 22 percent results in consistently higher growth rates.

The qualitative growth effects from the other policy experiments are similar to the region average. Despite a lower initial debt ratio, issuing public debt to fund public investment is harmful to growth, with the growth rate declining to 2.02 percent when debt is raised from 30 to 35 percent (achieved by increasing b_2 from 2 to 2.8). On the other hand, re-allocating public expenditure away from consumption and emphasizing investment in education and healthcare bring the greatest improvements to the growth rate.

4.4.3 "High Debt, Low Tax" scenario

The previous results carry over to the "High Debt, Low Tax" (HDLT) scenario, which is roughly representative of the Peruvian economy during 1990-2008. Table 7 provides the steady-state results in which the benchmark tax and debt ratios are 18.36 and 46.32 percent, respectively.[15] It is interesting to note that in this extreme scenario where such a large debt burden is underpinned by low tax revenue, a long run steady-state equilibrium which supports additional borrowing (i.e. increasing b_2 beyond 2.95) is not feasible. In this extreme case, debt financing public investment is not an option if the economy is to reach equilibrium in the long run. On the other hand, reducing the usage of debt considerably improves the growth rate, which rises to 2.6 percent when the debt level is lowered from 46 to approximately 44 percent. The growth effects of the remaining policy experiments are qualitatively similar to the region average and do not need to be discussed further.

To summarize, regardless of the initial fiscal condition, for the Latin American economies under consideration, financing additional public investment by debt will compromise growth in the long run. Where tax rates are not already high, funding public investment by raising taxes, in particular consumption taxes, may be a viable option to support long-run growth. If, however, tax rates are already high or other constraints to raising tax revenue exist, then

[15] The new benchmark was achieved by increasing the debt parameter, b_2, from 2 to 2.95. The tax rates and share of tax revenue allocated to public consumption expenditure, a_1, were also adjusted as indicated at the bottom of Table 7.

public investment should be funded by restructuring the composition of public spending. This may be accomplished by lowering the share of public consumption expenditure in favor of investment in public capital. In addition, even greater growth benefits can be achieved when public investment is carefully allocated to those sectors where its marginal productivity is largest. In our simplified model, re-allocating public investment from the final output sector toward intermediary human capital production enhances long-run growth.

5 Conclusion

In this paper we develop a dynamic micro-foundations growth model to explore how variations in the composition and financing of government expenditures affect economic growth in the long run. The model is used to analyze how public investment spending funded by taxes or borrowing affects long-term output growth. We also examine the effect of varying the composition of public expenditure, shifting between consumption and investment spending, or re-allocating between different types of public investment. Finally, by using alternative parameterizations of the model, we explore how the effects on growth depend on initial fiscal conditions such as high average tax rates and debt ratios.

We find that financing productive government expenditures with additional debt reduces growth in the long run. This negative impact obtains whether the economy has a high or low existing debt stock as additional borrowing not only raises current debt, but also increases debt servicing costs. Conversely, using tax financing for additional public investment can increase growth rates, as long as the optimal tax level has not been exceeded. This implies that for countries where the level of taxation is already high, tax increases are not a good option for funding public investment.

The analysis also underscores previous work which shows that public consumption expenditure can have a negative effect on growth so that reallocating away from consumption towards public investment can have tremendous positive growth effects in the long run.

More significantly, the results show that reallocating among public investment itself – that is, shifting from infrastructure towards greater emphasis on human capital formation – can have considerable growth pay-offs, regardless of the initial debt and taxation levels.

Interesting areas for future work would be to extend the current model to an open economy which can borrow from abroad at world interest rates. Less crowding-out effects from reduced domestic borrowing may allow for positive growth effects of specific debt-financed public investment (Glomm & Rioja, 2012). Another potentially worthwhile extension would be to account for the possibility of tax evasion which prevents increases in tax rates from translating into commensurate increases in tax revenue, thus limiting the effectiveness of tax policy to fund public investment.

6 References

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TABLES

Table 1

Selected Economic Indicators 1990-2008

Economic indicator	Argentina	Brazil	Chile	Colombia	Mexico	Peru	Venezuela	Average
Revenue (% GDP)[a]	20.0	21.3	24.4	29.3	16.0	15.1	23.2	21.3
Tax revenue (% GDP)[a]	14.3	16.7	17.8	13.1	11.1	13.2	13.1	14.2
Government expenditure (% GDP)[a]	19.0	15.6	18.9	30.6	22.8	14.4	24.7	20.8
Government consumption (% GDP)[b]	11.2	19.5	11.2	16.3	10.6	9.5	10.8	12.7
Public investment (% GDP)[c]	1.7	4.5	4.9	7.2	3.6	3.8	9.9	5.1
Public debt (% GDP)[a]	36.2	41.8	38.7	27.5	24.4	42.4	31.1	34.6
GDP p.c. growth (%)[b]	3.0	1.2	3.9	1.8	1.7	2.7	1.5	2.3
Private consumption (% GDP)[b]	68.1	61.9	61.7	66.2	67.8	70.6	58.3	64.9
Domestic investment (% GDP)[b]	18.2	18.0	23.6	20.2	23.4	20.6	21.9	20.8
Trade (% GDP)[b]	28.0	21.4	64.5	35.7	52.8	35.5	52.3	41.5
Capital-output ratio[d]	1.9	1.9	2.2	2.0	2.2	2.5	2.1	2.1
GDP p.c. (2000 US$)[b]	7580	3717	4735	2483	5654	2082	5037	4470
GDP p.c. PPP (2005 intl $)[b]	10128	7954	10163	6757	11500	5600	9998	8871

[a]Official statistics from public sector agencies in each country.

[b]Data sourced from World Bank's World Development Indicators.

[c]Public investment in infrastructure 2001-2006 from Calderon and Serven (2010).

[d]Author's calculations.

Table 2

Benchmark Parameters for Region Average

Parameter	Value	Definition
ρ	0.04	Rate of time preference
σ	2.00	Inverse of the inter-temporal elasticity of substitution in consumption
u	0.90	Share of human capital employed in private production
α	0.30	Elasticity of output, Y, w.r.t. educated labor (human capital)
β	0.15	Elasticity of output, Y, w.r.t. public capital in infrastructure
ε	0.30	Elasticity of the production of human capital w.r.t. public capital stock in education and health
A	0.85	Shift factor in final market production
Q	0.50	Shift factor in human capital production
		Fiscal Policy Variables
τ_K	0.15	Tax rate on capital income
τ_L	0.15	Tax rate on labor income
τ_C	0.20	Tax rate on consumption
v	0.90	Share of public capital stock employed in private production (public infrastructure)
a_1	0.60	Share of total tax revenue used to finance public consumption
b_2	2.00	Extent to which new bond issues are used to finance public investment. $b_2 > 1$ implies the use of debt financing.

Table 3

Benchmark Solution for Model Calibrated to Region Average

Economic indicator	LAC-7 average	Model
Revenue (% GDP)	21.3	23.5
Tax revenue (% GDP)	14.2	23.5
Government expenditure (% GDP)	20.8	18.7
Government consumption (% GDP)	12.7	14.1
Public investment (% GDP)	5.1	4.6
Public debt (% GDP)	34.6	36.7
GDP p.c. growth (%)	2.3	2.5
Private consumption (% GDP)	64.9	48.6
Domestic investment (% GDP)	20.8	22.3
Capital-output ratio	2.1	2.8

Note. The underlying equilibrium solutions are $c^* = 0.1715$, $b^* = 0.1295$, $g^* = 0.2590$, $h^* = 0.1230$, and $b_1^* = 0.9026$.

Table 4

Steady-State Results for Policy Experiments on the Region Average

	Growth rate	Public Inv.	Public Cons.	Debt Serv.	Debt	Taxes
Policy variable	γ	I_p/Y	C_p/Y	rB/Y	B/Y	T/Y
b_2 (debt)						
1.9	2.54	4.71	14.09	6.91	35.45	23.48
2.0	**2.50**	**4.59**	**14.12**	**7.12**	**36.68**	**23.54**
2.1	2.47	4.48	14.15	7.30	37.75	23.58
2.5	2.36	4.17	14.23	7.82	40.97	23.72
$\tau_K = \tau_L$ (income taxes)						
0.13	2.45	4.32	13.08	6.56	34.80	21.80
0.14	2.48	4.45	13.60	6.84	35.75	22.67
0.15	**2.50**	**4.59**	**14.12**	**7.12**	**36.68**	**23.54**
0.16	2.52	4.72	14.65	7.41	37.60	24.41
0.17	2.54	4.85	15.17	7.69	38.51	25.29
τ_C (consumption tax)						
0.18	2.44	4.41	13.60	6.86	35.59	22.66
0.19	2.47	4.50	13.86	6.99	36.14	23.10
0.20	**2.50**	**4.59**	**14.12**	**7.12**	**36.68**	**23.54**
0.21	2.53	4.67	14.38	7.25	37.21	23.96
0.22	2.56	4.76	14.63	7.37	37.73	24.39
a_1 (reallocating between public consumption and public investment)						
0.50	2.89	5.89	11.97	9.02	44.38	23.94
0.55	2.70	5.23	13.05	8.06	40.54	23.73
0.60	**2.50**	**4.59**	**14.12**	**7.12**	**36.68**	**23.54**
0.65	2.28	3.95	15.17	6.19	32.77	23.34
0.70	2.04	3.34	16.21	5.28	28.81	23.16
v (reallocating between infrastructure and human capital)						
0.80	3.19	4.65	14.06	7.05	33.49	23.44
0.85	2.90	4.63	14.08	7.08	34.75	23.47
0.90	**2.50**	**4.59**	**14.12**	**7.12**	**36.68**	**23.54**
0.95	1.84	4.51	14.19	7.20	40.33	23.65

Note. Benchmark case in bold type.

Table 5
Steady-State Results for "High Debt, High Tax" (HDHT) Scenario

	Growth rate	Public Inv.	Public Cons.	Debt Serv.	Debt	Taxes
Policy variable	γ	I_p/Y	C_p/Y	rB/Y	B/Y	T/Y
benchmark	**2.44**	**4.73**	**18.02**	**10.44**	**50.99**	**30.04**
b_2 (debt)						
3.1	2.42	4.68	18.01	10.50	51.39	30.02
3.5	2.37	4.53	18.02	10.72	52.81	30.04
$\tau_K = \tau_L$ (income taxes)						
0.22	2.45	4.92	19.13	11.11	52.87	31.88
0.24	2.50	5.10	20.30	11.80	54.70	33.80
0.26	2.45	5.25	21.40	12.52	56.47	35.66
0.28	2.44	5.40	22.56	13.24	58.17	37.60
τ_C (consumption tax)						
0.26	2.48	4.87	18.50	10.71	52.07	30.84
0.28	2.52	5.00	18.97	10.98	53.12	31.62
0.30	2.56	5.12	19.42	11.24	54.14	32.37
0.32	2.59	5.24	19.87	11.50	55.12	33.11
0.33	2.61	5.30	20.08	11.62	55.60	33.47
a_1 (reallocating between public consumption and public investment)						
0.50	2.80	5.99	15.02	13.03	60.95	30.04
0.55	2.63	5.36	16.52	11.73	56.04	30.04
v (reallocating between infrastructure and human capital)						
0.80	3.14	4.84	18.02	10.40	46.83	30.04
0.85	2.84	4.80	18.02	10.42	48.48	30.04

Note. The following parameters were changed to achieve the "high debt, high tax" benchmark: $\tau_K = \tau_L = 0.20$; $\tau_C = 0.24$; $b_2 = 3$. The underlying equilibrium solutions are $c^* = 0.1698$, $b^* = 0.1898$, $g^* = 0.2846$, $h^* = 0.1399$ and $b_1^* = 0.9475$.

Table 6

Steady-State Results for "Low Debt, Low Tax" Scenario

	Growth rate	Public Inv.	Public Cons.	Debt Serv.	Debt	Taxes
Policy variable	γ	I_p/Y	C_p/Y	rB/Y	B/Y	T/Y
benchmark	**2.21**	**3.56**	**10.68**	**5.34**	**29.86**	**17.80**
b_2 (debt)						
2.1	2.18	3.48	10.70	5.48	30.74	17.83
2.5	2.08	3.24	10.75	5.87	33.37	17.91
2.8	2.02	3.12	10.77	6.07	34.74	17.96
$\tau_K = \tau_L$ (income taxes)						
0.13	2.28	3.85	11.72	5.89	31.89	19.53
0.14	2.32	3.99	12.25	6.17	32.89	20.41
0.15	2.35	4.13	12.78	6.45	33.87	21.29
0.18	2.42	4.53	14.39	7.32	36.76	23.98
0.20	2.46	4.79	15.48	7.92	38.62	25.80
0.22	2.49	5.04	16.59	8.54	40.43	27.65
τ_C (consumption tax)						
0.18	2.33	3.85	11.52	5.75	31.71	19.20
0.20	2.40	4.04	12.06	6.02	32.88	20.10
0.22	2.46	4.22	12.58	6.28	34.00	20.97
0.25	2.55	4.49	13.34	6.65	35.61	22.23
0.26	2.58	4.58	13.58	6.77	36.13	22.64
a_1 (reallocating between public consumption and public investment)						
0.50	2.58	4.55	9.01	6.73	35.98	18.02
0.55	2.40	4.05	9.85	6.03	32.94	17.91
v (reallocating between infrastructure and human capital)						
0.80	2.87	3.61	10.63	5.28	27.27	17.72
0.85	2.60	3.59	10.65	5.31	28.29	17.76

Note. The following parameters were changed to achieve the "low debt, low tax" benchmark: $\tau_K = \tau_L = 0.11$; $\tau_C = 0.15$. The underlying equilibrium solutions are $c^* = 0.1705$, $b^* = 0.0971$, $g^* = 0.1942$, $h^* = 0.1081$ and $b_1^* = 0.9$.

Table 7

Steady-State Results for "High Debt, Low Tax" Scenario

	Growth rate	Public Inv.	Public Cons.	Debt Serv.	Debt	Taxes
Policy variable	γ	I_p/Y	C_p/Y	rB/Y	B/Y	T/Y
benchmark	**2.52**	**4.40**	**8.26**	**8.61**	**46.32**	**18.36**
b_2 (debt)						
2.5	2.60	4.63	8.23	8.20	43.72	18.28
$\tau_K = \tau_L$ (income taxes)						
0.13	2.60	4.76	9.10	9.51	49.54	20.23
0.15	2.67	5.12	9.96	10.44	52.69	22.13
0.18	2.75	5.63	11.28	11.88	57.29	25.06
0.20	2.79	5.96	12.18	12.87	60.26	27.07
0.25	2.86	6.74	14.54	15.48	67.42	32.30
0.28	2.88	7.17	16.02	17.14	71.51	35.59
τ_C (consumption tax)						
0.20	2.72	5.01	9.36	9.75	51.18	20.81
0.25	2.90	5.59	10.39	10.80	55.61	23.09
0.30	3.05	6.14	11.35	11.80	59.68	25.23
0.35	3.18	6.65	12.26	12.73	63.43	27.24
a_1 (reallocating between public consumption and public investment)						
0.35	2.82	5.32	6.53	10.31	53.57	18.64
0.40	2.67	4.85	7.40	9.46	49.95	18.50
v (reallocating between infrastructure and human capital)						
0.80	3.22	4.47	8.23	8.54	42.37	18.28
0.85	2.93	4.44	8.24	8.57	43.93	18.32

Note. The following parameters were changed to achieve the "high debt, low tax" benchmark: $\tau_K = \tau_L = 0.11$; $\tau_C = 0.15$; $a_1 = 0.45$; $b_2 = 2.95$. The underlying equilibrium solutions are $c^* = 0.1818$, $b^* = 0.1566$, $g^* = 0.2368$, $h^* = 0.1113$ and $b_1^* = 0.9189$.

APPENDIX

Table A1

Variations in the Elasticity of Production of Human Capital

	Benchmark $\varepsilon = 0.30$	$\varepsilon = 0.15$	$\varepsilon = 0.10$
v	(reallocating between infrastructure and human capital)		
0.90	2.50	2.02	1.81
0.85	2.90	2.26	1.98
0.80	3.19	2.43	2.09