Investing in Public Infrastructure: 
Roads or Schools?*

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Abstract

This paper analyzes public investment scaling-ups in economic and social infrastructure—say roads and schools—through the lens of a general equilibrium model. In the context of developing economies, investing in schools (relative to roads) is characterized by much larger long-run returns, but also by a much more pronounced intertemporal substitution of labor and crowding-out of private investment. Therefore, the public investment composition has profound repercussions on government debt sustainability, and is characterized by a trade-off, with important welfare implications. A myopic government would not invest in social infrastructure at all. The model predicts an horizon of at least thirty years for political leaders to start investing in schools and twice-as-long an horizon for the size of expenditures to be comparable to the socially-optimal level. A big-push in investments can mitigate concerns arising from myopia, but at the cost of worsening fiscal concerns, although in this case the relative disadvantage of investment in social infrastructure is considerably reduced.

Keywords: public investment, low-income developing countries, social spending, human capital, public debt sustainability

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1 Introduction

The notion that public investment in infrastructure is an important driver of economic growth can be found in much of the political discourse of poor economies, although it has recently gained revived momentum also in emerging markets and advanced economies alike. The World Economic Forum (2004) estimates global spending on infrastructure investment to amount to US$3.7 trillion per year, and yet a spending gap of at least US$1 trillion still exists every year.

In his seminal model, Rosenstein-Rodan (1943) argued that a “Big Push” of investment-led growth would enable an economy to loosen multiple constraints, to realize scale economies and to generate the needed demand. Since then, the literature has made a great effort in analyzing the macroeconomic impact of public infrastructure investment. Recent contributions have focused particularly on the nexus between government infrastructure spending and its effects on growth and public debt sustainability (see, e.g., Buffie et al., 2012; IMF, 2014; Abiad et al., 2015; Melina et al., 2016).

However, with the exception of a few contributions (see, e.g., Devarajan et al., 1996 and Agenor, 2010), these studies look at one broad measure of public infrastructure. Our paper shows, on one hand, that the composition of public investment has important macro-fiscal implications and, on the other hand, that these macro-fiscal considerations affect the welfare-optimal composition itself. In particular, we distinguish between what we label “economic” and “social” infrastructure.

By economic infrastructure we mean those capital goods that allow the economy to function (such as roads, railways, ports, water, power and telecommunications). By social infrastructure we mean those entities that primarily deliver social services (such as schools, universities and hospitals). In particular, in this paper, we model social infrastructure embedding elements that can be easily linked to schools and education. Therefore, for simplicity, in the remainder of the paper we often refer to economic infrastructure as “roads” and to social infrastructure as “schools”. It must be clarified that the distinction between the two categories of projects is not clearcut, as economic infrastructure has also a social component, just like social infrastructure has strong economic implications, as we emphasize.

Distinguishing between components of public infrastructure investment is not a trivial issue. In fact, governments continuously face the problem of maximizing the outcome from a wide variety of public goods subject to constrained budgets. Focusing on education spending is particularly relevant for developing economies (emerging markets and, a fortiori, low-income countries), which exhibit low stocks of human capital and a consistently lower levels of education spending as a fraction of GDP (see Figure 1). In the growth theory, a balanced growth path requires to equalize the marginal returns among

\[ 1 \text{To our knowledge, Hall and Jones (1999) were the first to define the concept of “social infrastructure”.} \]
different investments and their marginal costs dynamically. In the real world, the issue becomes more complex for two reasons: (i) each component of government investment contributes to economic growth at a different pace; and (ii) fiscal costs may be large, front-loaded, and sometimes irreversible.

It is with two issues in mind that, in this paper, we analyze the macroeconomic and public debt sustainability implications of the break-up between economic and social infrastructure in the context of a public investment scaling-up program, and we isolate important determinants of the welfare-optimal composition, including political myopia.

Our analytical framework is a single-good, small-open Dynamic General Equilibrium (DGE) model including, for the most part, rather established features. Less standard features include the accumulation of human capital, which is accrued via an optimal decision of households of postponing labor supply in order to spend time in schools, while the cost of building schools and maintaining all associated current expenditures is borne by the government. Economic infrastructure relatively quickly increases the productivity of private firms, whereas the scaling-up of education and school training enhances workers’ productivity, potentially to a larger extent, but only in the long run, and requiring similarly large upfront costs. Additionally, social infrastructure entails larger current expenditures, including for operations and maintenance. Concerns for debt sustainability constrain the magnitude of the fiscal space, and this generates a trade-off between the two types of public investments.

Calibrating the model to an average developing economy, our main results are as follows. Given the scarcity of human capital, if public investment were to be made exclusively in schools, this would result in a much larger long-run increase in output than in an opposite scenario in which public investment occurred exclusively in roads. Yet, for a prolonged time (around 15 years) the economy would enjoy faster growth rates by investing only in roads, and it takes about a generation (almost 24 years) for the additional output obtained by investing in schools to overtake that delivered by investing in roads. This has tremendous fiscal implications, with schools causing a threefold peak in government debt relative to roads.

A “big push”, i.e. a frontloading of investment expenditures, shrinks the delay by which the additional output delivered by schools overtakes the additional output delivered by roads, and this results also in much more similar, albeit amplified, public debt paths. However, the big push, by amplifying the intertemporal labor substitution effect associated with scaling-up schools, results also into a stronger medium-run drop in output and private consumption.

These tradeoffs have clear welfare implications. In fact, on one hand, from the households’ perspective, the welfare-optimal share of schools in the new investment drops from about 2/3 (with no big push) to about 1/2 when a big push is introduced in the government investment scaling-up. On the other hand, from the government’s perspective, if
political leaders have a time horizon of less than 30 years, they would not invest in schools at all; and an approximately double time horizon is needed for investment in schools to be of a comparable magnitude as in the case of a benevolent social planner. The costs of political myopia decrease with a big push, as this allows to anticipate some of the benefits from investing in schools.

Our paper adds to a large literature on the macroeconomic effects of public investment. The works by Barro (1990), Barro and Sala-i-Martin (1992), Futagami et al. (1993) and Glomm and Ravikumar (1994) investigate the impact of public investment in the context of endogenous growth models. Chatterjee and Turnovsky (2007), Agenor (2010), Buffie et al (2012), among others, make important remarks of how developing countries’ features affect the public capital accumulation and its impact on growth. Adam and Bevan (2006), Cerra et al. (2008), and Berg et al. (2010), among others, explore the macroeconomic effects of aid-financed public investment expansions. However, all these contributions abstract from the composition of public investment. Two papers are notable exceptions to this statement. In fact, Devarajan et al. (1996) and Agenor (2010) introduce the composition of public investment into the picture. However, Devarajan et al. (1996) considers a fixed total government spending while Agenor (2010) assumes a budget-neutral fiscal policy. In other words, neither paper allows for public debt accumulation and, hence, the relationship between investment composition and fiscal policy considerations is ruled out. All in all, our contribution to the existing literature is that, on one hand, the paper highlights that the break up of public investment expenditures matters both from a macroeconomic and a fiscal viewpoint; on the other hand it emphasizes that debt sustainability and government’s myopia intuitively affect the optimal investment composition.

The remainder of the paper is structured as follows. Sections 2 describes the model. Section 3 discusses the calibration. Section 4 presents the results. Finally, Section 5 concludes.

2 Model

We consider a single-good, small-open production economy populated by a continuum of identical households and firms that take prices as given. Investment in roads or increases firms’ productivity as, e.g., in Buffie et al. (2012). In addition, in this model, investment in schools increases the productivity of the process of human capital accumulation. While firms use both (private) capital and (social-capital adjusted) effective labor for goods production, the process for human capital accumulation uses effective labor as the only private input.

In equilibrium, in this economy, all non-stationary variables grow at the same rate, $g$,
driven by the exogenous growth in firms’ productivity.\textsuperscript{2} Thus, all non-stationary variables pertaining to time $t$, are normalized by dividing them by $(1 + g)^t$ and the description that follows refers to these normalized/stationary variables.

### 2.1 Firms

There is a continuum of perfectly competitive firms producing good $y_t$ by combining private capital, $k_{t-1}$, effective labor, $e^\chi l_t$, and government-supplied infrastructure, $z^i_{t-1}$, according to a Cobb-Douglas production technology:

$$y_t = A^\psi (z^{i}_{t-1})^\psi (k_{t-1})^\alpha (e^\chi l_t)^{1-\alpha},$$

(1)

where $\alpha$ and $\psi$ are the (private) capital share of output and the output elasticity of public capital, respectively; parameter $\chi > 0$ determines how human capital transforms raw labor into effective units of labor; and $A^\psi > 0$ is total factor productivity.

As firms are competitive, to maximize profits, their optimal (factor demands) decisions equate the marginal product of each input to its price:

$$\alpha \frac{y_t}{k_{t-1}} = r^k_t,$$

(2)

and

$$(1 - \alpha) \frac{y_t}{l_t} = w_t e^\chi,$$

(3)

where $r^k_t$ is the rental rate for capital and $w_t$ is the wage rate per unit of effective labor, which—unlike all other non-stationary variables—has been normalized/made stationary by dividing by $(1 + g)^{(1-\chi)t}$. However, it should be mentioned that the wage rate per unit of raw labor does grow at the rate $g$, like all other non-stationary variables.

### 2.2 Households

A representative household in the economy derives utility from consumption, $c_t$, and disutility from, $n_t$, i.e., the time spent in non-leisure activities. Consistent with balanced growth—as suggested by King, Plosser and Rebelo (1988)—we consider households’ preferences to be non-separable in consumption and leisure. In particular, the household maximizes

$$\sum_{t=0}^{\infty} \beta^t \left( \frac{c_t (1 - n_t)^{\kappa}}{1 - \frac{1}{\kappa}} - 1 \right),$$

(4)

where $\beta \equiv (1 + g)^{-1} (1 + g)^{1-\kappa} \in (0, 1)$ is the household’s discount factor and $\kappa$ is the pure rate of time preference. The elasticity of intertemporal substitution in consumption

\textsuperscript{2}Except for one exception that is discussed later.
is represented by $\kappa > 0$, while $\zeta > 0$ is a preference parameter controlling the degree of substitution between leisure and consumption (the so-called Frisch elasticity of labor supply).

There are two productive uses of household’s time $n_t$: they devote time $l_t$ for producing goods and time $u_t$ to accumulate human capital (by going to school). Thus, we have

$$n_t = l_t + u_t. \quad (5)$$

The household derives income from supplying labor and capital. In addition, it also receives firms’ profits $\Phi_t$ and transfers $\mathcal{T}_t$ from the government. The savings left after consumption are used to invest amount $I_t$ in private capital that depreciates at rate $\delta_k$, and to buy domestic bonds $b^d_t$ that pay a real interest rate $r^d_t$. Thus, the household faces the following intertemporal budget constraint:

$$(1 + \tau_t) c_t + I_t + b^d_t \leq w_t e^\gamma l_t + r^d_t k_{t-1} + (1 + r^d_{t-1}) \frac{b^d_{t-1}}{1 + g} + \mathcal{T}_t + \Phi_t, \quad (6)$$

where $\tau_t$ is the value-added tax on consumption, while the accumulation of private capital evolves according to the following law of motion:

$$(1 + g) k_t = (1 - \delta_k) k_{t-1} + I_t, \quad (7)$$

where $\delta_k$ is the depreciation rate of private capital.

### 2.2.1 Human capital Accumulation

Let us recall that, besides economic capital, the household can also accumulate human capital by spending time $u_t$ in schools. The process of education/schooling combines government-provided schools, $z_{t-1}^e$, and effective time, $e^\chi u_t$, to produce human capital according to the following technology:

$$A^e \left(z^e_{t-1}\right)^{\phi} (e^\chi u_t)^\nu, \quad (8)$$

where $A^e > 0$, $\phi > 0$, and $\nu > 0$ are parameters. In particular, $\phi$ is the elasticity of human capital output with respect to government-provided education infrastructure, i.e., schools, while $\nu$ is the elasticity with respect to effective schooling time.

The human capital accumulated via schooling increases the effectiveness of time/labor. However, in the model—as in the real world—it does so gradually given that various cohorts of school-going agents become part of the labor force over time. Notice that this inertia/delay in availability for productive use occurs for human capital and not for
economic capital.\(^3\) It is worth clarifying that this delayed effect of accumulated human capital on output is distinct from time-to-build arguments. Time-to-build delays in (overall) public investment would imply that investments in roads and schools would become part of their productive stocks with some delay. Typically models with time-to-build lags for economic capital (see, e.g., Leeper et al, 2010) are calibrated at a quarterly frequency and look at much shorter delays relative to human capital acquired via schooling. If we modeled time-to-build lags for roads and schools, such delays would affect both types of investments symmetrically. In contrast, our objective is to bring out a key difference between roads and schools more sharply: once a road is completed, it can be immediately used in a productive manner, while having built a school does not automatically translate into more human capital available to the economy; it will take several more years to train students who will become productive workers in the far future. As such, we abstract from time-to-build considerations.

The inertia in human capital accumulation is captured in the model by adding the output of human capital production process first to an intermediary stock of human capital, \(\xi_t\), which is currently trapped in schools. This stock evolves according to:

\[
(1 + g) \xi_t = (1 - \omega) \xi_{t-1} + A^\phi \left(z_{t-1}^e\right)^\phi \left(e_t^u u_t\right)^\nu, \tag{9}
\]

of which, every period, a fraction \(\omega\) moves from schools to the labor force. On average, newly accumulated human capital becomes productive with a delay of \(1/\omega\) periods. In particular, the productive human capital in the economy—i.e., that outside the schools—evolves according to:

\[
e_t = (1 - \delta_e) \frac{e_{t-1}}{1 + g} + \omega \xi_{t-1}, \tag{10}
\]

where \(\delta_e\) is the depreciation rate of the human capital.

### 2.2.2 Household’s Optimization

To simplify household’s optimization problem, we eliminate \(I_t\) from (6) using (7) to obtain:

\[
(1 + \tau_t) c_t + (1 + g) k_t + b_t^d \leq w_t e_t^u l_t + (1 + r_t^k - \delta_k) k_{t-1} + (1 + r_t^d) \frac{b_{t-1}^d}{1 + g} + T_t + (\Phi L)
\]

The representative household chooses \(c_t, l_t, u_t, e_t, \xi_t, b_t^d, \) and \(k_t\) to maximize (4) subject to (11), (9), and (10), after eliminating eliminating \(n_t\) from (4) using (5). Let \(\lambda_{1,t}, \lambda_{2,t}, \) and \(\lambda_{3,t}\) be the Lagrange multipliers corresponding to these constraints. The first-order

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\(^3\)To be specific, it occurs only for human capital accumulated via schooling, which we seek to model here. For example, it would not be the case for the accumulation of human capital through on-the-job training.
conditions for the problem (with some simplifications) are then given by:

\[
\begin{align*}
    c_t : & \quad \frac{c_t(1-l_t-u_t)}{c_t} = \lambda_{1,t} (1 + \tau_t), \\
    l_t : & \quad \xi[c_t(1-l_t-u_t)]^{1-\frac{1}{h}} = \lambda_{1,t} w_t \xi_t, \\
    u_t : & \quad \xi[c_t(1-l_t-u_t)]^{1-\frac{1}{h}} = \lambda_{2,t} \frac{\nu A^e (z_{t-1}^e)^{\phi} (e_t^x u_t)^{\nu}}{u_t}, \\
    k_t : & \quad (1 + g) \lambda_{1,t} = \beta \lambda_{1,t+1} (1 + r_{t+1}^k - \delta_k), \\
    b_t : & \quad r_t^d = r_{t+1}^k - \delta_k, \\
    \xi_t : & \quad (1 + g) \lambda_{2,t} = \beta [(1 - \omega) \lambda_{2,t+1} + \omega \lambda_{3,t+1}], \\
    e_t : & \quad \lambda_{3,t} = \lambda_{1,t} \frac{w_t e_t^x l_t}{e_t} + \lambda_{2,t} \frac{\nu A^e (z_{t-1}^e)^{\phi} (e_t^x u_t)^{\nu}}{e_t} + \beta \lambda_{3,t+1} \frac{1 - \delta_e}{1 + g}.
\end{align*}
\]

The first five equations (12)-(16) are fairly standard. Equation (17) states that the value of a unit of human capital in school (on the left-hand side) is equal to the sum of the present discount value of the \((1 - \delta)\) units of human capital left in school and \(\omega\) units of human capital (available to transform raw labor into effective labor) in the next period. Similarly, equation (18) equates the value of one unit of human capital to the sum of its benefit in terms of higher current wage income, the marginal value in production of new human capital, and the present discount value of the undepreciated social capital for the next period.

### 2.3 Government

The government makes investment \(g^e_t\) in economic infrastructure and \(g^e_t\) in education infrastructure, which augments their stocks according to:

\[(1 + g) z_t^j = (1 - \delta_t^j) z_{t-1}^j + g_t^j, \quad \text{for} \quad j = e, i,\]

where \(\delta_t^j\) is the rate of deprecation of the corresponding stock of infrastructure.

We follow Adam and Bevan (2014) and include operation and maintenance costs of public capital and model these expenditures, \(m_t\), as a constant proportion of the stock of the public capital so that

\[m_t^j = \gamma_t^j z_{t-1}^j \quad \text{for} \quad j = e, i,\]

where \(\gamma_t^j > 0\). This extension is motivated by the need to capture empirically relevant differences in the size of these expenditures for economic versus social infrastructure, which have implications for the relative benefits of the two types of public investments.

In addition to investing in and maintaining infrastructure, the government also makes
transfers $T_t$ to the households. Its revenues come from a value-added tax on consumption, and grants and other revenues, $G_t$. The deficit is financed through either domestic borrowing $\Delta b^d_t = b^d_t - b^d_{t-1}$ or external concessional borrowing $\Delta b^x_t = b^x_t - b^x_{t-1}$. Thus, the government’s budget constraint is

$$\Delta b^x_t + \Delta b^d_t = m^x_t + g^x_t + T_t + \left(r^d_{t-1} - g\right) \frac{b^d_{t-1}}{1+g} + \left(r^x_{t-1} - g\right) \frac{b^x_{t-1}}{1+g} - \tau_t c_t - G_t.$$  \hspace{1cm} (21)

where

$$m^x_t \equiv m^x_t + m^i_t,$$ \hspace{1cm} (22)

$$g^x_t \equiv g^x_t + g^i_t,$$ \hspace{1cm} (23)

are total (current) maintenance and (capital) investment expenditures.

While the government initially may have both domestic and foreign debt, we assume that it only issues either new domestic or foreign debt, but not both at the same time. Thus,

$$\Delta b^x_t \text{ or } \Delta b^d_t = 0.$$ \hspace{1cm} (24)

The (real) interest rate $r^x_t$ on external debt/borrowing is given by

$$r^x_t = r^f + v^y e^{v^y \left( \frac{b^x_t}{w^y} - \frac{v^x_t}{w^x} \right)}.$$ \hspace{1cm} (25)

where $v^y > 0$ and $v^x > 0$ are parameters and $r^f$ is the risk-free world real interest rate. Thus, the economy faces an upward sloping supply of foreign funds. This is one of the standard ways of eliminating the (only) unit root in dynamic behavior of this small-open economy.

### 2.3.1 Fiscal Adjustment

We next turn to the fiscal adjustment mechanism of the government. Given the path of public investment, the fiscal gap before policy adjustment ($\text{Gap}_t$) is given by

$$\text{Gap}_t = g^x_t + m^x_t + \left(r^d_{t-1} - g\right) \frac{b^d_{t-1}}{1+g} + \left(r^x_{t-1} - g\right) \frac{b^x_{t-1}}{1+g} + T_t - \tau_t c_t - G_t.$$ \hspace{1cm} (26)

It corresponds to excess of expenditures (including interest payments) over revenues, keeping transfers and taxes constant at reference values $\bar{\tau}_t$ and $\bar{T}_t$ which evolve as follows:

$$\bar{\tau}_t = x_f + \rho_x (\bar{\tau}_{t-1} - x_f), \quad \text{for } x = \tau, T,$$ \hspace{1cm} (27)
where \( \bar{x}_{-1} = x_0 \), and \( x_o \) and \( x_f \) denote initial and final steady-state values of \( x \). While \( \tau_f \) is determined endogenously, we set \( \mathcal{T}_f = \mathcal{T}_o \times (y_f/y_o) \) so that transfers scale with output across steady states.

The definition of fiscal gap in equation (26) can be used to write the budget constraint as

\[
\text{Gap}_t = \Delta \%x_t + \Delta \%d_t + (\tau_t - \%\tau_t) c_t - \left( \mathcal{T}_t - \mathcal{T}_f \right). \tag{28}
\]

Equation (28) shows that the gap \( \text{Gap}_t \) can be covered by domestic and/or external commercial borrowing, and adjustment of taxes and/or transfers. However, borrowing (domestic or external) can be used only in the short or medium term so as to keep the debt sustainable. Thus, eventually, the VAT and transfers must adjust to cover the entire gap. The reaction functions that accomplish the required adjustments include the following debt-stabilizing values for VAT and transfers

\[
\%\tau_t^{\text{target}} = \%\tau_t + (1 - \lambda) \frac{\text{Gap}_t}{c_t}, \tag{29}
\]

and

\[
\%\mathcal{T}_t^{\text{target}} = \mathcal{T}_t - \lambda \text{Gap}_t, \tag{30}
\]

where \( \lambda \in [0, 1] \) is a policy parameter controlling the division of the fiscal adjustment between taxes and transfers. When \( \lambda = 0 \) the burden of adjustment falls fully on taxes and vice versa for \( \lambda = 1 \).

The fiscal reaction functions themselves are

\[
\%\tau_t = \%\tau_{t-1} + \lambda_{\tau,1} \left( \%\tau_t^{\text{target}} - \%\tau_{t-1} \right) + \lambda_{\tau,2} \frac{(b^x_{t-1} + b^d_{t-1})}{y_t} - \left( b^x + b^d \right)^{\text{target}}, \tag{31}
\]

and

\[
\%\mathcal{T}_t = \%\mathcal{T}_{t-1} + \lambda_{\mathcal{T},1} \left( \%\mathcal{T}_t^{\text{target}} - \%\mathcal{T}_{t-1} \right) + \lambda_{\mathcal{T},2} \frac{(b^x_{t-1} + b^d_{t-1})}{y_t} - \left( b^x + b^d \right)^{\text{target}}, \tag{32}
\]

where \( (b^x + b^d)^{\text{target}} \) is the new (steady state) level of government debt that is specified exogenously.

Our fiscal adjustment mechanism reduces to that of Buffie et al. when the shock is temporary and reflects the desire of the government to smooth out policy changes as rapid fiscal adjustment is painful. As a result, in response to a change in policy (or any shock), the government will typically reach fiscal policy targets consistent with zero fiscal gap over time. In the meantime, it will adjust its borrowing to meet fiscal obligations. However, it also implies that the later part of the transition is characterized by smaller transfers and higher taxes than target values to generate fiscal surpluses to pay down accumulated debt.

The complete specification of the government policy also requires specifying the path
of total investment expenditure, $g^i_t$, and its breakup between investment in roads and schools. Let $s^i_t$ be the share going to roads, then we have

$$g^i_t = s^i_t g^r_t.$$  \hspace{1cm} (33)

### 2.4 Market Clearing and External Balance

Combining the household’s budget constraint (6) and the government’s budget constraint (21), and using homogeneity of the production function in private factors yields the following external balance condition for the economy:

$$- \left( b^e_t - \frac{b^x_{t-1}}{1 + g} \right) = y_t + G_t - \frac{r^x_t}{1 + g} b^x_{t-1} - (m^e_t + g^r_t + c_t + I_t),$$  \hspace{1cm} (34)

where the left-hand side is the negative of the capital/financial account and the right-hand side is the current account.

Goods market clearing requires aggregate output to equate aggregate demand:

$$y_t = c_t + I_t + g^r_t + m^e_t + nx_t,$$  \hspace{1cm} (35)

where $nx_t$ represents net exports, using which we obtain the current account as

$$ca_t = nx_t + G_t - r^x_{t-1} \frac{b^x_{t-1}}{1 + g}.$$  \hspace{1cm} (36)

Finally, the assumptions of competitive markets and constant returns to scale in production in private factors imply zero firms’ profits, so that

$$\Phi_t = 0.$$  \hspace{1cm} (37)

The economy’s behavior is described by the system consisting of 35 equations: (1-3), (5), (7), (9-10), (12-18), (19a-19b), (20a-20b), (22-26), (27a-27b), (28-37) in the following 35 variables: $y_t$, $c_t$, $I_t$, $k_t$, $n_t$, $u_t$, $u_t$, $e_t$, $\xi_t$, $b^d_t$, $b^e_t$, $\Phi_t$, $r^e_t$, $w_t$, $r^d_t$, $r^r_t$, $\lambda_{1t}$, $\lambda_{2t}$, $\lambda_{3t}$, $z^e_t$, $z^r_t$, $g^r_t$, $g^e_t$, $m^e_t$, $m^r_t$, $m^r_t$, $\tau_t$, $\tau_t$, $\frac{\tau_{t \text{target}}}{\tau_{t \text{target}}}$, $\tau_{t \text{target}}$, $nx_t$, $ca_t$, and $\Phiap_t$, given the exogenous value of $(b^e + b^d)_{\text{target}}$ and exogenous paths for $g^r_t$ and $G_t$.

### 3 Calibration

The model is simulated using annualized values for an average low-income country (LIC), with the calibration reflecting a mixture of observable data, estimates, and guesstimates, which follows Buffie et al. Table 1 summarizes the baseline calibration used throughout the computation.
• **Elasticity of intertemporal substitution** ($\kappa$). Most estimates for LDC lie between 0.10 and 0.50 (see Agenor and Montiel, 1999). Our base case value, 0.34, is the average estimate for LICs in Ogaki et al. (1996).

• **Proportion of non-leisure time and leisure preference parameter** ($n_0, \zeta$). We chose to set the proportion of non-leisure time to 0.36 in the initial equilibrium—a practice common in real DSGE model of RBC vintage. This results in $\zeta = 1.1648$. The implied Frisch elasticity of labor supply is 1.0051, which is within the range of empirical estimates.

• **Capital’s share in value added** ($\alpha$). Data on factor shares may be found in social accounting matrices (for example, see those from the Global Trade Analysis Project (GTAP) and the International Food Policy Research Institute (IFPRI)). The GTAP5 database for SSA suggests a capital share of 55-60% in the non-tradables sector and 35-40% in the tradables sector. The data in Thurlow et al. (2004) and Perrault et al. (2010) suggest similar numbers, although with a lot of variation (see Thurlow et al., 2008). As the size of the two sector is typically approximately equal, we set $\alpha = 0.475$, the average of the mid-point of the estimates for the two sectors.

• **Return to economic infrastructure and elasticity of output with respect to the stock of economic infrastructure** ($R^i_z, \psi$). Both micro and macro evidence on the balance points to a high average return on economic infrastructure, although actual estimates vary a lot. A comprehensive study of World Bank project from around 2001 found the median rate of return of 20% in SSA that varied from 15% to 29% for various sub-categories of economic infrastructure investment. The macro-based estimates in Dalgaard and Hansen (2005) paint a similar picture with most estimates in 15%-30% range for a wide array of different estimators. Some micro estimates from Foster and Briceno-Garmendia (2010) suggest returns for electricity, water and sanitation, irrigation, and roads ranging from 17% to 24%. Hulten et al. (2006), Escribano et al. (2008), Calderon et al. (2009), and Calderon and Serven (2010) supply additional evidence of high returns. Thus, high returns appear to be the norm and we consider a high-return scenario as the base case by setting $R^i_z = 0.25$ at the initial equilibrium. The values assigned elsewhere in calibrating the model, along with the return on infrastructure, pin down $\psi$ and we obtain a value of 0.1123.

• **Speed of transition of human capital from schools to the labor force** ($\omega$). Under the assumption that education infrastructure in the model refers to schools from K-12,

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4For a critique of studies using infrastructure stock arrived at using perpetual inventory method which find low or insignificant returns, unlike those based on physical measures, see Straub (2008).
\( \omega = .08 \), so that human capital becomes part of labor force after an average delay of \( 1/\omega \approx 12 \) periods after acquisition.

- **Return to schools and parameters of the human capital accumulation process** \((R^e_z, \chi, \phi, \nu)\). Estimates of the return on education/schools are even more varied than for the return on economic infrastructure. However, it is generally agreed the return on public investment in education is much higher than that on investment in roads. Accordingly, we set \( R^e_z = 0.40 \) in the initial equilibrium.\(^5\) In addition, we make an agnostic assumption that (the non-stationary counterparts of) the total factor productivities in both goods and human capital production, \( A^y \) and \( A^e \), grow at the same rate. Finally, we fix the proportion of non-leisure time devoted to schooling \( (\frac{\omega}{n_o}) \) to .10 in the initial equilibrium. These three restrictions imply \( \chi = 0.6911 \), \( \phi = 0.5467 \), and \( \nu = 0.5838 \).

- **Depreciation rates** \((\delta_k, \delta^e_z, \delta^i_z, \delta^e)\). Given the paucity of data on depreciation rates in LICs, we use a value of 5% for economic capital (private, roads, and schools), which is a typical value for the developed countries. Due to the lack of additional information, we also choose same value for \( \delta^e \), the depreciation rate for human capital.

- **Trend growth rate** \((g)\). The trend growth rate is set at 1.5%, the 1990-2008 per-capita growth rate for SSA based on African Development Indicators as reported in Buffie et al. (2012).

- **Real interest rate on domestic bonds and (gross) real return on private capital** \((r^d, r^k)\). Real interest rates vary considerably across countries and over time. We set the domestic real interest rate at 10% in the initial steady state consistent with Fedelino and Kudina’s (2003) estimates for SSA as well as with the return on private capital estimated by Dalgaard and Hansen (2005). With this choice, the domestic debt in low- and middle-income countries is more expensive than external commercial debt in accordance with the stylized facts. The real interest rate on domestic debt and the (net of depreciation) real return on private capital equal \((1 + \varrho)(1 + g)^\kappa - 1\) in the steady state, where \( \varrho \) is the subjective discount rate. With values of \( \kappa \) and \( g \) chosen above, the target for real interest rate yields the value of \( \varrho \).

\(^5\)Recall, the effect of schools on output through increased effectiveness of labor (via \( e \)) happens slowly over time or with a gradual delay, which is in contrast to the effect of economic infrastructure on output. The computation of the return to schools takes this delay into account. In particular, we calculate the stream of additional output (net of depreciation) resulting from an initial one unit increase in investment in schools in the initial equilibrium. The stream is discounted to the initial period using the market interest rate \((r^d)\). The return to schools is then simply \( r^k \) times this present value.
• Risk-free world real interest rate, real interest rate of foreign borrowing, and debt risk premium parameters \((r^f, r^x, v_g, \eta_g)\). We fix the world real interest rate at a standard value of 4%. It also approximates the historical averages of the real returns on stocks and government bonds (3-10 year T-bills) in the United States. In 2015, Angola and Gabon issued B+ rated Eurodollar bonds amounting to $1.5 billion and $500 million with interest rates of 9.5% and 6.96%, respectively. Their average is close to Gueye and Sy’s (2010) estimate: according to them, SSA, excluding Seychelles and South Africa, pays an average interest rate of 8.55% on international debt. After assuming a 2.5% world (traded goods) inflation, this yields a 6% (initial) real interest rate in dollars which equals the value for \(r^x\) in the initial equilibrium and, in turn, implies \(v_g = .02\). Thus, the risk premium is set at 2%. While van der Ploeg and Venables (2011) provide positive estimate \(\frac{1}{g} = 1.89\), we initially assume that the risk premium is constant so that \(\frac{1}{g} = 0\). Later on, we do sensitivity analysis for different values of \(\eta_g\) for certain exercises where it is important.

• Domestic debt \((b^d_o)\). As there is a lot of variation across studies, our choice of 20%, is based on the average of the figures reported in Panizza (2008), IMF (2009), and Arnone and Presbitero (2010).

• Public external debt \((b^x_o)\). We assume that initially the economy has no access to foreign borrowing implying that \(b^x_o = 0\).

• Grants and other revenues \((G_o)\). The grants are assumed to be 4% of GDP in the initial equilibrium, which is close to the average for LICs in the last decade. We also assume that other revenues, such as those from natural resources, are zero.

• Initial ratio of capital investment and current spending to GDP for roads and schools \((\frac{\varphi^r}{y_o}, \frac{\varphi^s}{y_o}, \frac{m^r}{y_o}, \frac{m^s}{y_o})\), current expenditure on roads and schools as fraction of the stocks of roads and schools \((\gamma^r, \gamma^s)\), and fraction of government capital expenditure on roads \((s^r)\). We set the initial total public capital expenditure to be equal to 6% of GDP, close to the LIC SSA average of 6.09% for 2008 according to Briceno-Garmendia et al. (2008). As they note, this figure also includes the net investment associated with trend growth and current expenditure (the outlays on operations and maintenance \((O+M))\), which average about 3.4% of GDP for the LICs in SSA. We assume that two thirds of the investment is made in roads and one third in schools. Adam and Bevan (2014) note considerable variation in the ratio of (re)current expenditure to installed capital, with the number being (much) larger for social infrastructure like schools than economic infrastructure like roads. Accordingly, we set this ratio to 70% for schools and 50% for roads which yields the average value of 56.7% as in data. The chosen values are within the range of estimates in Heller (1991). The values of \((\gamma^r, \gamma^s)\) follow in a straightforward manner from the initial ratios for capital
investment and current spending on infrastructure and schools. In particular, $\gamma_s^i = 0.0650$ and $\gamma_c^e = 0.1517$. Finally, the fraction of government capital expenditure on roads ($s^i$) turns out to be 0.7692.

- **Consumption VAT** ($\tau$). The consumption VAT in the model proxies for the average indirect tax rate. Our rate of 15% at the initial steady state is comparable to the average VAT of 15.8% for LICs for 2005-06 estimated from data by the International Bureau of Fiscal Documentation.

- **Net Transfers** ($T_o$). At the initial steady state, transfers ensure that the budget constraint of the government holds. This translates into $T_o = 7.9376$ percent of GDP. Given the definition of the other fiscal variables, this concept of transfers includes other taxes different from VAT as well as non-capital expenditures such as public wages.

- **Division of fiscal adjustment between expenditure cuts and tax increases** ($\lambda$). We assume that only taxes share the burden of fiscal adjustment ($\lambda = 0$).

- **Speed of adjustment of reference values for computing the fiscal gap** ($\rho_r, \rho_T$). To be consistent with a slow adjustment of the economy to the new steady state equilibrium, these autoregressive parameters are set to very close to 1. Specifically, both are assigned a value of 0.99.

- **Policy reaction parameters** ($\lambda_{r,1}, \lambda_{r,2}, \lambda_{T,1}, \lambda_{T,2}$). There are no estimates of these parameters for LICs. For the scenarios that allow commercial debt accumulation or domestic debt accumulation we set $\lambda_{r,1} = \lambda_{T,1} = 0.25$ and $\lambda_{r,2} = \lambda_{T,2} = 0.02$.

4 **Scaling up of Public Expenditure on Infrastructure**

The paper seeks to compare and contrast the effects of a public investment scaling-up in schools and roads. We consider an increase in combined public investment and current expenditure to the tune of 1% of initial GDP. This implies a scaling up of 16.7% in real terms, which is modest relative to a 50% scaling up from 6% to 9% of GDP considered in Adam and Bevan (2014) or the levels considered in Buffie et al. (2012). Qualitative implications are, however, independent of the size of the scaling-up. Similar to Adam and Bevan (2014), the scaling up in expenditures considered is permanent (long-term), whereas Buffie et al. (2012) focused on the (short-term) temporary case. A permanent scaling up, that is, a longer-term perspective in expenditure planning, is deemed to be more appropriate and natural in the current setting of a choice between roads and schools, since the effects of better schools on output through the accumulation of human capital
operate gradually over a long time span.\footnote{To be specific, as the economy grows at the rate $g$, a permanent increase of 1% of initial GDP in normalized terms implies that the expenditure also grows over time at the rate $g$.} While in Subsection 5.1 we show the trade-offs between a scaling-up of public investment exclusively in roads versus one that occurs entirely in schools, in Subsection 5.2 we seek the optimal composition of the scaling-up itself.

4.1 Growth Effects and Debt Sustainability Implications of Roads versus Schools

4.1.1 A Permanent Policy Shift

In this subsection we undertake a positive comparative analysis of public investment scaling-up in roads and schools. Two scenarios are examined: one in which the scaling-up occurs entirely in roads; the other in which it all happens in schools. This exercise is intended to shed light on how the shift from investment in roads to schools affects the macroeconomic dynamics. In order to make the two cases comparable we keep the increase in total expenditure (including both capital and current expenditures) the same across the two cases.

Given that investment in schools has higher returns, it is expected to result in higher growth in the long run. At the same time, it is likely to give rise to some serious trade-offs. Qualitatively, the trade-off is fairly intuitive. While investment in schools is more attractive and would result in higher output in the longer run, the increase occurs only gradually, when compared to the alternative of investing in roads. This, in turn, forces the government to rely more on debt financing when investing in schools, exacerbating debt sustainability concerns.

The intuition described above is confirmed by the model simulations reported in Figure 2 and 3, where total infrastructure expenditures rise from 6% to 7% of GDP. Figure 2 clarifies how the scaling-up is apportioned to the various spending items. Let us first consider the scenario with the whole investment scaling-up occurring in roads. In this case total expenditure on roads rises permanently from 4% to 5% of GDP. As current expenditures are initially unchanged, the increase shows up entirely as increase in capital expenditures in roads which rise from 2% to 3% of GDP. However, the gradual increase in current expenditures, concomitant with the rise in the stock of roads, causes some of the committed resources to be directed away from capital expenditures (augmenting the stock of roads) and into current expenditures. In the long run, both investment and current expenditures on roads evenly split the 1% increase (both rise from 2% to 2.5% of GDP). Let us now turn to the scenario with entire investment scaling-up occurring in schools. Since running schools requires proportionately larger current expenditure, in the long run, the split between capital and current expenditures is 30%-70%, respectively.
(with investment increasing from 0.6% to 0.9% and current expenditures jumping from
1.4% to 2.1% of GDP).

Figure 3 illustrates the macroeconomic implications of the two alternative scenarios.
The trade-off is rather stark and clear. Investment in schools results in a long-run increase
in output (above the underlying trend) of 24% compared to a much smaller increase of
5% obtained with an exclusive investment in roads. Yet, for first 13 years, the economy
enjoys faster growth rates (over and above the exogenous growth rate of $g$) when the
public investment is made in roads rather than in schools. In fact, growth dips below
its trend for about 9 years with investment in schools, whereas it stays above the trend
if the investment is made in roads. The initial disadvantage of investment in schools
accumulates over time and it takes 24 years for the additional output obtained by investing
in schools to overtake that delivered by investing in roads.

In the initial 20 years or so of the simulations, the differences in private consumption
across the two scenarios is, however, much more moderate. The reason lies in that
relatively larger future increases in productivity generated by investment in schools result
in a stronger wealth effect (due to the larger increase in permanent income) and and
intertemporal substitution of labor towards the future, increasing the time they spend at
school in the first 20 years or so. Since output rises only slowly over time (actually it falls
initially due to the intertemporal effect) and agents cannot borrow from abroad, private
investment falls in the short run. In short, (relatively) lower output with investment in
schools is matched by a (relatively) lower private investment demand with consumption
responding marginally.

As government ramps up investment, and consumption (its tax base) and revenues
responds little on impact, the resulting fiscal deficit increases public debt. In particular,
it increases external debt (not shown in Figure 3) because we are considering the case
in which the government finances deficits only via international borrowing. The latter
in turn results in current account deficits. As public debt builds up over time, the fiscal
rule implies an increase in the consumption tax rate. While the described mechanism
operates in a similar manner across both scenarios, the quantitative effects differ signifi-
cantly. While public debt rises by about 2% of GDP for investment in roads, investment
in schools results in almost a threefold increase of 6% of GDP.\textsuperscript{7} Perhaps more impor-
tantly, investment in schools results in a more persistent increase in public debt as a
fraction of GDP, posing more prolonged risks to debt sustainability. In our example,
while investment in roads increases the debt burden for a period of 30 years, investment
in roads leads to an increase in public debt that lasts around 60 years.

\textsuperscript{7}If the model featured income/output-based taxation instead of a consumption-based tax, the dif-
fferences would be larger because output differences are much larger across the two scenarios than con-
sumption differences. Putting it another way, a movement from income to consumption-based taxation
would reduce the disadvantage of investment in schools in terms of debt sustainability implications.
4.1.2 A Permanent Policy Shift with a Big Push

Typically, policy shifts signaling greater public investment are accompanied by a “big push” in the short run. Increases in public investments of the order of 5 to 10 percent of GDP for several years are not uncommon. A number of papers have analyzed growth and debt sustainability implications of these big pushes. For example, Maldives is currently undertaking investment of 35%-38% of GDP to upgrade its tourism infrastructure over a period of 4 year from 2016 onwards (see IMF, 2016). Andreoli and Abdychev (2016) analyze debt sustainability implication of Lesotho’s construction of a hydropower plant with total investment of about 31% of GDP over a period of 7 years. In this subsection, we study how the comparative analysis of growth and debt sustainability implications of long-run investment in roads versus schools is affected in the likely scenario of an accompanying big push in the short run.

We use a second-order delay function as in Melina et al. (2016) to model the short-run big push. In particular, we set the short run increase, as a percent of GDP, over and above the long-run 1% rise, as $14(e^{-2t} - 2e^{-9t})$. The results with big push are shown in Figure 4. The big push nearly doubles public expenditure from 6% to almost 13% in first 2 years and it remains over 8% for about 14 years.

Some aspects of the simulations results are straightforward, others need some explanations. As expected, the big push generates additional investment and hence a quicker transition to the long-run growth outcome. For instance, for the case of investment in schools, the transition is almost complete in 60 years compared to more than 100 years in absence of the big push. Interestingly, for investment in roads, in the medium run the big push takes growth well above the long-run outcome. Moreover, it is noteworthy that—with the big push—output, private consumption and private investment, under the scenario of all investment in schools, overtake their counterparts obtained investing all in roads 4-5 years earlier (in about 20 years) than in the scenarios without the big push.

In the same vein, big push considerations tilt the balance in favor of investment in schools when viewed from the perspective of taxes and debt. True, the big-push results in a higher tax and debt burden in the initial years of the policy change. However, first the duration for which taxes and debt rise is much shorter in both scenarios. In particular, public debt (as a fraction of GDP) comes back to the original level, and below, within 20 years, and this happens because GDP rises much faster. Second, and most importantly, the pronounced differences between the paths for consumption taxes

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8Djibouti ramped up public investment from about 12-14% of GDP to as much as 30% of GDP over 2013-2015 (see IMF, 2016a). See IMF (2016b) for the analysis of the Maldives’ currently undergoing investment of 35%-38% of GDP to upgrade its tourism infrastructure over a period of 4 year from 2016 onwards. Andreoli and Abdychev (2016) analyze debt sustainability implication of Lesotho’s construction of a hydropower plant with total investment of about 31% of GDP over a period of 7 years. In the context of big-push scenarios, Ghazanchyan et al. (2016) study how improving the efficiencies of capital spending and of tax revenue collection affect growth and debt sustainability in Cambodia, Sri Lanka, and Vietnam.
and public debt presented in Figure 3 (with no big push) vanish in Figure 4. In other
words, the handicap of schools vis-a-vis roads from a fiscal perspective almost vanishes
with a big push.

A very important caveat is that while investment in schools overtakes investment in
roads earlier in terms of various criteria in the presence of a big push, the short-run
costs terms of private consumption (and output) are much higher. This has significant
welfare implications, as we show below. The big push, by accelerating the benefits of
investment in education, significantly strengthens the intertemporal (labor) substitutions
effects causing labor supply to decline sharply in the medium run than with a permanent
policy shift alone. The consequent decline in output also reduces private consumption.

4.2 “Optimal” Composition of the Public Investment Scaling-Up

The analysis in previous section highlight the tension between investment in roads versus
schools. One provides smaller, but immediate returns with less challenges to debt sustain-
ability while other results in larger gains far out into the future with associated risks for
debt sustainability. Given that these two extreme scenarios provide such differing profiles
of benefits and costs, it may be useful to consider an intermediate scenario which can
leverage strengths of both to deliver a better overall outcome. In particular, we consider
a government policy choosing a constant split of the scaling up of infrastructure between
roads and schools such that households’ welfare is maximized.

Figure 5 shows how households’ welfare varies with the share of expenditure allo-
cated to schools. We first consider the permanent policy shift of a scaling-up of public
investment of 1% in the long run without the big push (left panel). In this case, the
optimal share of education is high at 76%. When big push considerations are factored
in (right panel), the optimal share comes down from 76% to 50%. As discussed in the
previous subsection, the big push has two opposing effects on the comparative benefits of
investment in roads versus schools. On the one hand, school investment catches up with
investment in roads faster in terms of consumption, output, tax, and debt. On the other
hand, short-run costs in terms of consumption are much higher. The increase in short-
run costs outweighs the acceleration benefits so that the optimal share of investment in
schools goes down significantly.

In Figure 6 and 7 the corresponding equilibrium paths of macro variables are overlaid
on the earlier two scenarios produced without and with a big push, respectively. The
paths of the variables for the optimal break up are sandwiched between those of the
two scenarios. Without the big push these are closer to those for the scenario with all
investment in schools, given the high optimal share of schools in this case. With the big
push, the paths of the macro variables are more clearly in-between the two extreme cases.
All in all, the optimal break-up of public investment into roads and schools improves welfare vis-a-vis all investment in schools by trading some of the future gains far into the future with those in the present. It also reduces (to a small extent) the distortionary effects of higher taxation and risks of debt sustainability, the former being implicitly accounted for in the welfare comparison.

4.3 Myopic Social Planner and Optimal Investment break-up

It is well known that the decisions of political incumbents are quite often not aligned with the interests of the general population. For example, the literature on political economy studies how (at least partially) selfish political leaders distort the provision of public goods to enhance their chances of getting re-elected.

We introduce these political considerations into the model to shed light on how such practical realities may affect the optimal break-up of the public investment scaling-up in roads and schools. The adverse impact of their selfish desire for getting re-elected is modeled as their myopia in evaluating the benefits of various policies. Specifically, the incumbents disregard the benefits of policies that arise after a certain time horizon. A fully selfless (or altruistic) leader/planner has an infinite time horizon. The greater the selfishness, the higher the myopia, the shorter the time horizon. The ranking of policies is still based on agents’ discounted utility, yet summed over limited time horizons to capture leaders’ myopia.

In Figure 8, we plot the welfare-maximizing share of schools in the in the public investment scaling-up as a function of the social planner’s time horizon, both for the case with no big push (left panel) and for the case with big push (right panel). In the former case, a planner with a horizon of less than 30 years would not at all invest in schools. A time horizon of 60-70 years is needed to take a myopic leader’s desired share close to that of a completely altruistic social planner with infinite horizon. In the latter case, the threshold for no investment in schools falls to 20 years and it takes 45-55 years to get to a share comparable to that of the altruistic social planner. The cost of myopia of political leaders falls with a big push as it brings the benefits of investment in schools forward in time. Therefore, from a policy perspective, the adverse effects of a leader’s myopia can be mitigated by incorporating a big push in their infrastructure scaling-up.

5 Conclusions

There is a large literature on the macroeconomic effects of public investment. However, most of this literature abstracts from the composition of public investment. We show that the break up of public investment becomes important when different components contribute to growth at a different pace, e.g., roads versus schools. In such a scenario,
the choice of this composition has important macro-fiscal implications. We examine these issues in a model with public debt and show that governments may fail to invest enough in schools despite their higher returns relative to roads for two reasons (i) debt sustainability and fiscal concerns, and (ii) the myopia of the policy makers. These reasons are related to the fact that fiscal costs of investments are front-loaded and growth benefits of investing in schools, while larger in the long run, accrue at a much slower pace than those of investing in roads. A big-push in investments can mitigate concerns arising from myopia of policy makers but at the cost of exacerbating the threat to fiscal and debt-sustainability. However, in relative terms, the calculus of fiscal concerns almost eliminates the disadvantage of investing in schools.

References


Table 1: Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\kappa$</td>
<td>0.3400</td>
<td>Intertemporal elasticity of substitution of consumption</td>
</tr>
<tr>
<td>$n_o$</td>
<td>0.3600</td>
<td>Initial proportion of time used for non-leisure activities</td>
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<td>Initial return on infrastructure</td>
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<td>Elasticity of output with respect to infrastructure</td>
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<td>$\lambda_{r,1}, \lambda_{T,1}$</td>
<td>0.2500</td>
<td>Fiscal policy reaction parameters for policy instruments</td>
</tr>
<tr>
<td>$\lambda_{r,2}, \lambda_{T,2}$</td>
<td>0.0200</td>
<td>Fiscal policy reaction parameters for debt</td>
</tr>
</tbody>
</table>
Figure 1: Education Spending Across Country Income Groups

Source: Government Finance Statistics, IMF
Figure 2: A Permanent Increase In Public Infrastructure: Current and Capital Expenditures Associated to Investing All In Roads Versus All In schools

Notes: Aggregate shock size: 1% of initial steady-state GDP; x-axis in years; y-axes in percent of initial steady-state GDP).
Figure 3: A Permanent Increase In Public Infrastructure: Effects On Key Macroeconomic Variables Associated To Investing All In Roads Versus All In Schools

Notes: Aggregate shock size: 1% of initial steady-state GDP; x-axis in years; y-axes in percent deviations from initial steady state, unless otherwise indicated.
Figure 4: A Permanent Increase In Public Infrastructure With A “Big Push” In The Short Run: Effects On Key Macroeconomic Variables Associated To Investing All In Roads Versus All In Schools

Notes: Long-Run Aggregate shock size: 1% of initial steady-state GDP, with a big push; x-axes in years; y-axes in percent deviations from initial steady state, unless otherwise indicated.
Figure 5: Share Of Schools In the Public Investment Scaling-Up And Associated Welfare

(a) Without “Big Push”

(b) With “Big Push”

Figure 6: Effects Of The Optimal Break-Up Of The Public Investment Scaling-Up On Key Macroeconomic Variables: Without The “Big Push”

Notes: Aggregate shock size: 1% of initial steady-state GDP; x-axes in years; y-axes in percent deviations from initial steady state, unless otherwise indicated.
Figure 7: Effects Of The Optimal Break-Up Of The Public Investment Scaling-Up On Key Macroeconomic Variables: With The “Big Push”

Notes: Long-Run Aggregate shock size: 1% of initial steady-state GDP, with a big push; x-axes in years; y-axes in percent deviations from initial steady state, unless otherwise indicated.

Figure 8: Optimal Share Of Schools In The Public Investment Scaling-Up: The Effect of Government’s myopia

(a) Without “Big Push”  
(b) With “Big Push”