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INVESTING IN PUBLIC INFRASTRUCTURE: ROADS OR SCHOOLS?

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Why do governments in developing economies favor roads rather than schools in public investment scale-ups? We study this question using a dynamic general equilibrium model and argue that the different pace at which roads and schools contribute to economic growth, public debt intolerance, and political myopia are central to this decision. In a thought experiment with a large return differential in favor of schools, a benevolent government would intuitively devote the majority of an investment scale-up to them. However, the fraction of schools chosen by the government falls with increasing levels of debt intolerance and political myopia. In particular, political myopia is a meaningful explanation for the observed result to the extent that an extremely myopic government would not invest in schools at all.

Keywords: Public Investment, Human Capital, Debt Sustainability, Political Myopia, Debt Intolerance, Developing Countries

1. INTRODUCTION

The notion that public investment is an important driver of economic growth can be found in much of the political and economic discourse on developing economies. In 2015, world leaders endorsed the United Nations' Sustainable Development Goals (SDGs) as the road map to more inclusive growth and

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development. For many of these goals—including education, health, roads, electricity, and water sanitation—public investment plays a crucial role. In fact, the uncertainty surrounding the returns on these investments and the typically long time horizon required for their materialization do not square well with the preferences of the private sector. In addition, as argued in the seminal paper by Rosenstein-Rodan (1943), many believe that a "big push" of public investment would enable an economy to loosen multiple constraints, benefit from economies of scale, and generate the needed demand to sustain higher growth. Gaspar et al. (2019) estimate that, in emerging market economies, delivering on the SDG agenda by 2030 would require an average additional spending of 4% points of GDP per year. Low-income developing countries (LIDCs) face an even bigger challenge as the spending increase needed would be on average as large as 15% points of GDP per year.

The macroeconomic literature has made a great effort in analyzing the macroeconomic impact of public 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), Araujo et al. (2016), Melina et al. (2016)). In the empirical literature, some authors have looked at disaggregated data of public investment (see Acosta-Ormaechea and Morozumi (2017) and references therein), but—with the exception of a few contributions (see, e.g., Devarajan et al. (1996) and Agenor (2010))—macroeconomic models typically look at one broad measure of public infrastructure. Our paper shows, in a general equilibrium setting, that *the composition of public investment has important macro-fiscal implications*, and that these considerations, in turn, affect its welfare-optimal composition. In particular, we distinguish between what we label "economic" and "social" infrastructure.[1]

By *economic infrastructure*, we mean the capital inputs that allow the economy to function better (such as roads, railways, ports, water, power, and telecommunications). By *social infrastructure*, we mean the capital that primarily delivers social services (such as schools, universities, and hospitals). In particular, this paper embeds elements that are directly related to schools and education. Therefore, for simplicity, we refer to economic infrastructure as "*roads*" and to social infrastructure as "*schools*" in the remainder of the paper. It must be clarified that the distinction between the two categories of projects is not always clear-cut, as economic infrastructure often has also a social component, just like social infrastructure has strong economic implications as we emphasize throughout the paper.

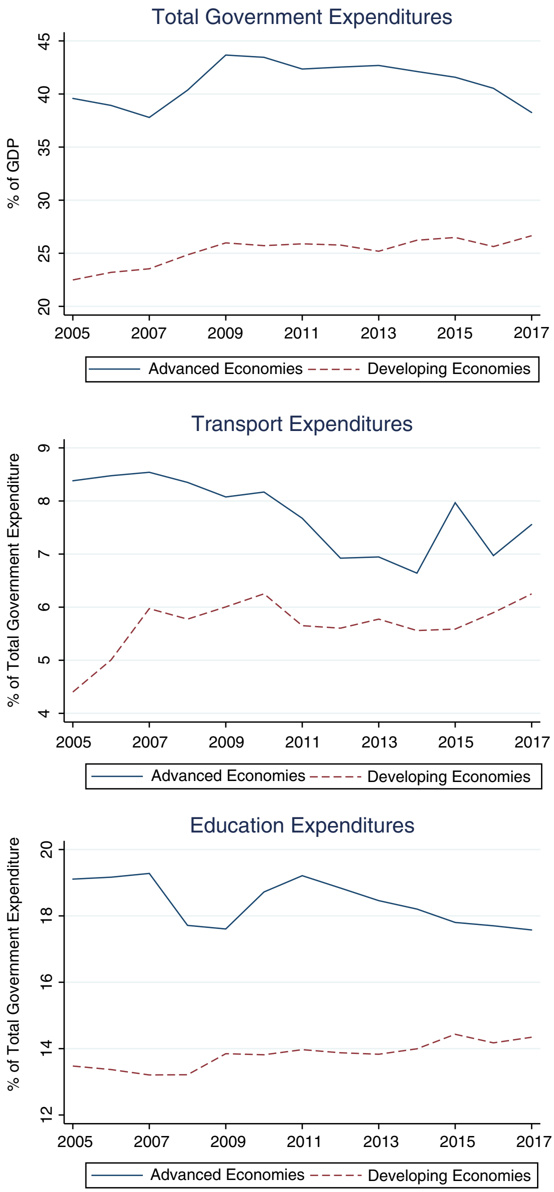
Econometric evidence demonstrates that focusing on schools is particularly relevant for developing economies. Acosta-Ormaechea and Morozumi (2017), using disaggregated public spending data for 83 countries with different levels of income, show that spending reallocations from roads to schools has growth-promoting effects. More importantly, these effects are significant only when a country's income level is low. Along the same lines, using a panel of 30 developing countries, Bose et al. (2007) had previously shown that an increase in spending on schools, financed by nontax revenue, results in higher growth, whereas an increase in spending on roads does not.

However, at the margin, we do not observe a preference for schools in the spending behavior of governments in the developing world from analyzing public spending data. On average, we observe a steady increase in government expenditures as a fraction of developing countries' GDP, from 23 to 27% of GDP from 2005 to 2017 (Figure 1). In levels, the share of schools (proxied by education expenditures) in total spending was higher than the share of roads (proxied by transportation expenditures). However, the relative changes of the two shares over time were not consistent with the higher return of schools at the margin. While the share of roads increased by about 2% points over the same time horizon, the share of public spending to schools increased by less than 0.5% points. In addition, while the gap of the expenditure share of roads in developing countries relative to advanced economies had narrowed to about 1% point in 2017, for spending on schools this gap was more than 3.5% points in the same year.

This paper therefore addresses the following question: Why do governments in developing economies favor roads rather than schools in public investment scale-ups? We study this issue in a model with a realistic and detailed specification of fiscal policy that includes distortionary taxation and public debt dynamics. With these features, the difference in the pace with which roads and schools contribute to economic growth (for a given public investment plan) turns out to be of central importance to the policymaker's optimal allocation decision. We begin our analysis by examining the macroeconomic and (public) debt sustainability implications of investment in roads versus schools in the context of an infrastructure scale-up program. Then, we deal specifically with our research question by looking at the welfare-optimal composition of a public investment scale-up. Besides the return differential between the two types of public investment—an obvious key determinant of the optimal share—debt intolerance and, to a larger extent, political myopia turns out to be powerful explanations of the observed preference for roads.

Our analytical framework is a single-good, small-open dynamic general equilibrium model including, for the most part, rather established features. Less standard features include the accumulation of human capital, which is accrued via postponing labor supply (and leisure) in order to spend time in schools, while the capital cost of building schools and the current expenditures to maintain them are borne by the government. Scaling up economic infrastructure increases the productivity of the private sector relatively quickly, whereas investment in schools raises workers' productivity mostly in the long run—albeit potentially to a larger extent—for similarly large upfront costs, adjusted for larger current expenditures (operations and maintenance) for schools.

We calibrate the model to an average developing economy and consider the thought experiment of a permanent increase in public expenditures. Given the empirical evidence, our baseline experiment assumes that the return on schools is larger than that on roads (as empirically shown by Bose et al. (2007) and Acosta-Ormaechea and Morozumi (2017)). This assumption implies that if public



Sources: IMF government finance statistics.

FIGURE 1. Average shares of "Roads" and "Schools" in government expenditures.

investment were to be made exclusively in schools, it would result in a larger long-run increase in output than in an opposite scenario in which public investment occurred exclusively in roads. However, an important and less obvious

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dynamic trade-off is at play. For a prolonged time (around 9 years), the economy enjoys faster growth by investing only in roads, and it takes about 20 years for the output obtained by investing in schools to overtake that delivered by investing in roads. This has tremendous fiscal implications, with schools causing a twofold peak increase in government debt relative to roads.

These trade-offs also have clear welfare implications. First, in our baseline, a benevolent government with an infinite time horizon and moderate debt intolerance chooses a fraction of the investment scale-up dedicated to schools equal to about three-fourths. It is noteworthy that, despite a large return differential in favor of schools, the dynamic trade-off explained above makes it still optimal for the government to devote a quarter of the new investment to roads. Second, the optimal share of schools drops for increasing degrees of debt intolerance. Third, we look at policymakers' time horizon. We model the adverse impact of political leaders' desire for getting reelected as their "myopia" in evaluating the benefits of various policies beyond a certain time frame. This can be rationalized in the case of asymmetric information between voters and politicians, with voters using current GDP growth as a signal to evaluate politicians when reelecting them. It must be emphasized that a political incumbent's time horizon (for evaluating benefits) is not the same as the duration of their incumbency. The former will typically be longer than the latter, reflecting the policymaker's desire to establish his legacy or the forward-looking behavior of the people who elect them. The model predicts that political leaders who have a planning horizon of less than 20 years would not invest in schools at all; more than double a time horizon is needed for investment in schools to be of a comparable magnitude to the case of a benevolent infinite-horizon social planner.

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 on how developing countries' features affect public capital accumulation and therefore growth. Adam and Bevan (2006), Cerra et al. (2008), and Berg et al. (2010*a*,b), on the other hand, explore the macroeconomic effects of aid-financed increases in public investment. However, all these contributions abstract from the composition of public investment. Two papers are notable exceptions: Devarajan et al. (1996) and Agenor (2010) introduce the composition of public investment into the picture. However, Devarajan et al. (1996) consider 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 twofold. On one hand, the paper shows that, to an extent, proper consideration of government's genuine macroeconomic and debt sustainability concerns can explain why policymakers may be reluctant to spend on schools relative to roads.

On the other, it highlights that policymakers' myopia may play a big role in this decision, as it turns out to be a powerful determinant of 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. Section 5 explores key determinants of the welfare-optimal composition of the public infrastructure scale-up. Finally, Section 6 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. Public investment in roads increases firms' productivity. In addition, investment in schools increases the productivity of the process of human capital accumulation. While firms use both (private and public physical) capital and (human capital adjusted) effective labor for goods production, the process for human capital accumulation uses effective labor as the only private input.

As discussed later, technology for both output and human capital in the calibrated model has diminishing returns in accumulable factors (physical and human capital). Thus, along the balanced growth path, all nonstationary variables grow at the same rate, g, driven solely by the exogenous growth in productivity, as in the setups of Buffie et al. (2012) and Zanna et al. (2019) without human capital.[2] Thus, all nonstationary 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, $e_t^{\chi} l_t$, and government-supplied infrastructure, z_{t-1}^i, according to a Cobb–Douglas production technology:

$$y_t = A^y \left(z_{t-1}^i\right)^{\psi} \left(k_{t-1}\right)^{\alpha} \left(e_t^{\chi} l_t\right)^{1-\alpha}, \tag{1}$$

where $\alpha \in (0, 1)$ and $\psi \in (0, 1)$ are the (private) capital share of output and the output elasticity of public capital, respectively; parameter $\chi > 0$ determines how human capital, e_t, transforms raw labor, l_t, into effective units of labor; and $A^y > 0$ is total factor productivity.

Firms are perfectly competitive and maximize profits by equating the marginal product of each input to its price, which yields the following optimal decisions (or factor demands):

$$\alpha \frac{y_t}{k_{t-1}} = r_t^k, \tag{2}$$

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and

$$(1-\alpha)\,\frac{y_t}{l_t} = w_t e_t^{\chi}, \tag{3}$$

where r_t^k is the rental rate for capital and w_t is the wage rate per unit of *effective* labor, which—unlike all other nonstationary variables—has been normalized by dividing by $(1+g)^{(1-\chi)t}$. This implies that the wage rate per unit of *raw* labor grows at the rate g, like all other nonstationary variables.

2.2. Households

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

$$\sum_{t=0}^{\infty} \beta^t \left(\frac{\left[c_t\,(1-n_t)^{\zeta}\right]^{1-\frac{1}{\kappa}} - 1}{1-\frac{1}{\kappa}} \right), \tag{4}$$

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

$$n_t = l_t + u_t. \tag{5}$$

The household derives income from supplying labor and capital to firms. In addition, it also receives firms' profits Φ_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 $\delta_k \in (0,1)$ and generates per-unit rental income r_t^k, and to buy domestic bonds b_t^d that pay a real interest rate r_t^d. Thus, the household faces the following intertemporal budget constraint:

$$(1+\tau_t)\,c_t + I_t + b_t^d \le w_t e_t^{\chi}\, l_t + r_t^k k_{t-1} + \left(1 + r_{t-1}^d\right)\frac{b_{t-1}^d}{1+g} + \mathcal{T}_t + \Phi_t, \tag{6}$$

where τ_t is the value-added tax (VAT) on consumption, while the accumulation of private capital evolves according to the following law of motion:

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

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2.2.1. Human capital accumulation. Recall that, besides physical capital, the household can also accumulate human capital by spending time u_t in schools. The process of schooling combines government-provided schools, z_{t-1}^e, and effective time spent to produce human capital, $e_t^\chi u_t$, according to the following technology:

$$A^e \left(z_{t-1}^e\right)^\phi \left(e_t^\chi u_t\right)^\nu ,$$

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

The human capital in the economy, thus, evolves according to:

$$(1+g)\, e_t = (1-\delta_e)\, e_{t-1} + A^e \left(z_{t-2}^e\right)^\phi \left(e_{t-1}^\chi u_{t-1}\right)^\nu , \tag{8}$$

where δ_e is the depreciation rate of the human capital. Note that the additional flow of human capital from schools in period $t-1$ adds to the stock of human capital, e_t, available at the beginning to period t.

2.2.2. Household's optimization. To simplify the household's optimization problem, we eliminate I_t from (6) using (7) to obtain

$$(1+\tau_t)\, c_t + (1+g)\, k_t + b_t^d \leq w_t e_t^\gamma l_t + (1 + r_t^k - \delta_k) k_{t-1} + \left(1 + r_{t-1}^d\right) \frac{b_{t-1}^d}{1+g} + \mathcal{T}_t + \Phi_t. \tag{9}$$

The representative household chooses c_t, l_t, u_t, e_t, b_t^d, and k_t to maximize (4)—after eliminating n_t using (5)—subject to (9) and (8). Let $\lambda_{1,t}$ and $\lambda_{2,t}$, be the Lagrange multipliers corresponding to these constraints. The first-order conditions for the problem are then given by:

$$c_t: \quad \frac{\left[c_t(1-l_t-u_t)^\zeta\right]^{1-\frac{1}{\kappa}}}{c_t} = \lambda_{1,t}\,(1+\tau_t), \tag{10}$$

$$l_t: \quad \frac{\zeta\left[c_t(1-l_t-u_t)^\zeta\right]^{1-\frac{1}{\kappa}}}{1-l_t-u_t} = \lambda_{1,t} w_t e_t^\chi, \tag{11}$$

$$u_t: \quad \frac{\zeta\left[c_t(1-l_t-u_t)^\zeta\right]^{1-\frac{1}{\kappa}}}{1-l_t-u_t} = \frac{\beta}{1+g}\lambda_{2,t}\frac{\nu A^e \left(z_{t-1}^e\right)^\phi \left(e_t^\chi u_t\right)^\nu}{u_t}, \tag{12}$$

$$k_t: \quad (1+g)\,\lambda_{1,t} = \beta\lambda_{1,t+1}\left(1 + r_{t+1}^k - \delta_k\right), \tag{13}$$

$$b_t: \quad (1+g)\,\lambda_{1,t} = \beta\lambda_{1,t+1}\left(1 + r_t^d\right), \tag{14}$$

$$e_t: \quad \lambda_{2,t} = \lambda_{1,t}\chi\frac{w_t e_t^\chi l_t}{e_t} + \beta\frac{\lambda_{2,t+1}}{1+g}\left[\frac{\chi\nu A^e \left(z_{t-1}^e\right)^\phi \left(e_t^\chi u_t\right)^\nu}{e_t} + 1 - \delta_e\right]. \tag{15}$$

The first five equations (10)–(14) are fairly standard. Equation (15) equates the (shadow) price of one unit of human capital to the sum of its benefit in terms of higher current wage income and present discounted value of both its marginal

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value in production of new human capital and the value of the undepreciated human capital in the next period. Combining equations (13) and (14) leads to the following no-arbitrage condition between holding private capital and government bonds, which equalizes the return on government bonds with the net return on private capital:

$$r_t^d = r_{t+1}^k - \delta_k.$$

2.3. Government

The government makes investment g_t^i in economic infrastructure (roads) and g_t^e in social infrastructure (schools), which augments their stocks according to:

$$(1+g)\, z_t^j = (1-\delta_z^j) z_{t-1}^j + g_t^j, \qquad \text{for} \quad j = e, i, \tag{16a–16b}$$

where $\delta_z^j \in (0, 1)$ is the rate of depreciation of the corresponding stock of infrastructure.[3]

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

$$m_t^j = \gamma_z^j z_{t-1}^j, \qquad \text{for} \quad j = e, i, \tag{17a–17b}$$

where $\gamma_z^j > 0$. This extension is motivated by the need to capture empirically relevant differences in the size of these expenditures for roads versus schools, which have implications for the (relative) time profile of the costs and benefits of the two types of public investments. In the case of schools, costs for operations and maintenance also include the cost of teachers, educational materials, and consumables.

In addition to investing in and maintaining infrastructure, the government also makes transfers $\mathcal{T}_t$ to households. Its revenues come from a VAT on consumption, $\tau_t c_t$, and grants and other revenues, $\mathcal{G}_t$. The last item, $\mathcal{G}_t$, is particularly relevant for developing economies as many of them have significant grants-in-aid (as a fraction of GDP) from international sources as well as significant revenues from non-fiscal sources, such as, operations of state-owned enterprises and royalties on exports of natural resources.

The deficit is financed through either domestic borrowing $\Delta b_t^d = b_t^d - b_{t-1}^d$ or external concessional borrowing $\Delta b_t^x = b_t^x - b_{t-1}^x$. Thus, the government's budget constraint is

$$\Delta b_t^x + \Delta b_t^d = m_t^z + g_t^z + \mathcal{T}_t + \left(r_{t-1}^d - g\right) \frac{b_{t-1}^d}{1+g} + \left(r_{t-1}^x - g\right) \frac{b_{t-1}^x}{1+g} - \tau_t c_t - \mathcal{G}_t, \tag{18}$$

where

$$m_t^z \equiv m_t^e + m_t^i, \tag{19}$$

$$g_t^z \equiv g_t^e + g_t^i \tag{20}$$

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are total operations and maintenance (current) and investment (capital) expenditures, respectively.

While the government may initially 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,

$$\Delta b_t^x = 0 \quad \text{or} \quad \Delta b_t^d = 0. \tag{21}$$

The (real) interest rate r_t^x on external debt/borrowing is given by

$$r_t^x = r^f + \upsilon_g e^{\eta_g \left(\frac{b_t^x}{y_t} - \frac{b_O^x}{y_O} \right)}, \tag{22}$$

where $\upsilon_g > 0$ and $\eta_g > 0$ are parameters and r^f is the risk-free world real interest rate.[4] 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 as suggested by Schmitt-Grohe and Uribe (2003).

2.3.1. Public investment and macroeconomic dynamics. We need to emphasize that the two types of public investments (in roads and schools) have very different effects on the path of the economy. To understand the reason for this difference, let us trace out the effects of a one-time extra investment in roads and schools, ignoring, for now, the depreciation of roads, schools, and human capital. A one-time extra investment in roads causes an immediate and permanent increase in the economy's output. In the case of schools, such one-time extra investment causes an (immediate and permanent) increase in the *flow* of human capital from schools. Thus, the *stock* of human capital keeps on rising continuously, thereafter; and along with it, so does the output of the economy. In either case, there may also be further second-order increases in output due to other factors, such as a possible increase in private capital.

Once the depreciation of various types of capital (roads, schools, and human capital) is factored in, these effects will be muted. To be specific, for an extra investment in roads, the one-time, immediate increase in the stock of roads and output will no longer be permanent, but it will be completely nullified in the long run by depreciation. For schools, there will be two effects in operation. First, the depreciation of schools will cause the extra flow of human capital to keep falling over time. Second, as the human capital stock rises, the associated increase in the depreciation of human capital will cause the net increase in human capital to fall over time, even for a fixed extra flow of human capital from schools.

In the end, the key difference arising from the differences in the technologies of human capital and physical capital accumulation is the following. For roads, the largest impact on output is immediate because roads enhance a production technology; for schools, the largest impact on output is delayed because schools enhance an investment technology. When combined with other features of the economy, such as distortionary taxation, debt intolerance, and myopia (discussed later), this difference in the dynamics triggered by investments in roads and schools becomes an important driver of the results we obtain in the paper.

2.3.2. Fiscal adjustment. We next turn to the fiscal adjustment mechanism of the government. Given the path of public investment, we can rearrange the government's budget constraint and express the government's fiscal gap before policy adjustment ($\mathfrak{Gap}_t$) as, for example, in Buffie et al. (2012) and Zanna et al. (2019):

$$\mathfrak{Gap}_t = g_t^z + m_t^z + \left(r_{t-1}^d - g\right)\frac{b_{t-1}^d}{1+g} + \left(r_{t-1}^x - g\right)\frac{b_{t-1}^x}{1+g} + \overline{\mathcal{T}}_t - \overline{\tau}_t c_t - \mathcal{G}_t. \quad \textbf{(23)}$$

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

$$\overline{x}_t = x_f + \rho_x\left(\overline{x}_{t-1} - x_f\right), \qquad \text{for} \quad x = \tau, \mathcal{T}, \quad \textbf{(24a–24b)}$$

where $\overline{x}_{-1} = x_o$, x_o and x_f denote initial and final steady-state values of x, and ρ_x is a smoothing parameter for the fiscal adjustment. While τ_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 (23) can be used to write the budget constraint in terms of its financing as

$$\mathfrak{Gap}_t = \Delta b_t^x + \Delta b_t^d + (\tau_t - \overline{\tau}_t)\, c_t - \left(\mathcal{T}_t - \overline{\mathcal{T}}_t\right). \quad \textbf{(25)}$$

Equation (25) shows that the gap $\mathfrak{Gap}_t$ can be covered by domestic and/or external borrowing, and fiscal adjustment through taxes and/or transfers. However, to keep debt sustainable, the borrowing (domestic or external) can be used only in the short or medium term. Thus, eventually, the VAT rate 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

$$\tau_t^{target} = \overline{\tau}_t + (1-\lambda)\frac{\mathfrak{Gap}_t}{c_t}, \quad \textbf{(26)}$$

and

$$\mathcal{T}_t^{target} = \overline{\mathcal{T}}_t - \lambda\mathfrak{Gap}_t, \quad \textbf{(27)}$$

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

$$\tau_t = \tau_{t-1} + \lambda_{\tau,1}\left(\tau_t^{target} - \tau_{t-1}\right) + \lambda_{\tau,2}\frac{\left(b_{t-1}^x + b_{t-1}^d\right) - \left(b^x + b^d\right)^{target}}{y_t}, \quad \textbf{(28)}$$

and

$$\mathcal{T}_t = \mathcal{T}_{t-1} + \lambda_{\mathcal{T},1}\left(\mathcal{T}_t^{target} - \mathcal{T}_{t-1}\right) + \lambda_{\mathcal{T},2}\frac{\left(b_{t-1}^x + b_{t-1}^d\right) - \left(b^x + b^d\right)^{target}}{y_t}, \quad \textbf{(29)}$$

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

Our fiscal adjustment mechanism reduces to that of Buffie et al. (2012) 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 a 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 the accumulated debt.

The complete specification of the government policy also requires specifying the path of total expenditure, $g_t^z + m_t^z$, and its breakup between spending on roads and schools. Let ϖ^e be the share going to schools (and $\varpi^i = (1 - \varpi^e)$ for roads), then we have the total spending on schools given by

$$g_t^e + m_t^e = \varpi^e\left(g_t^z + m_t^z\right), \quad \textbf{(30)}$$

and since current expenditures on schools, m_t^e, are a fraction of the stock of social infrastructure, we can rewrite the total capital expenditures on schools as

$$g_t^e = \varpi^e\left(g_t^z + m_t^z\right) - m_t^e.$$

2.4. Market Clearing, External Balance, and Equilibrium Definition

Combining the household's budget constraint (6) and the government's budget constraint (18), and using the homogeneity of the production function in private factors yield the following external balance (or balance of payments) condition for the economy

$$-\left(b_t^x - \frac{b_{t-1}^x}{1+g}\right) = y_t + \mathcal{G}_t - \frac{r_{t-1}^x}{1+g}b_{t-1}^x - \left(m_t^z + g_t^z + c_t + I_t\right), \quad \textbf{(31)}$$

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

$$y_t = c_t + I_t + g_t^z + m_t^z + nx_t, \quad \textbf{(32)}$$

where nx_t represents net exports. Using these two, we can obtain the current account

$$ca_t = nx_t + \mathcal{G}_t - r_{t-1}^x\frac{b_{t-1}^x}{1+g}. \quad \textbf{(33)}$$

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

$$\Phi_t = 0. \tag{34}$$

DEFINITION: *A perfect foresight equilibrium is a set of prices, allocations, and government policies, represented by* $\{y_t, c_t, I_t, k_t, n_t, l_t, u_t, e_t, b_t^d, b_t^x, \Phi_t, r_t^k, w_t, r_t^d, r_t^x, \lambda_{1,t}, \lambda_{2,t}, z_t^i, z_t^e, g_t^i, g_t^e, m_t^i, m_t^e, m_t^z, \tau_t, \mathcal{T}_t, \overline{\tau}_t, \overline{\mathcal{T}}_t, \tau_t^{target}, \mathcal{T}_t^{target}, nx_t, ca_t, \mathfrak{Gap}_t\}_{t=0}^{\infty}$ *such that, given the exogenous value of* $(b^x + b^d)^{target}$ *and paths for* g_t^z *and* $\mathcal{G}_t$*, the system consisting of 33 equations, (1)–(3), (5), (7), (8), (10)–(15), (16a–16b), (17a–17b), (19)–(23), (24a–24b), (25)–(34), holds.*

3. CALIBRATION

The model is simulated at an annual frequency, with the calibration reflecting a mixture of observable data, estimates, and guesstimates for an average low-income country. All investment returns cited throughout the paper are on an annual basis. Table 1 summarizes the baseline calibration used throughout the computation.

- *Elasticity of intertemporal substitution* (κ). Most estimates for LIDCs lie between 0.10 and 0.50 (see Agenor and Montiel (1999)). Our base case value, 0.34, is the average estimate for LIDCs in Ogaki et al. (1996).
- *Proportion of non-leisure time and leisure preference parameter* (n_o, ζ). We chose to set the proportion of non-leisure time to 0.36 in the initial equilibrium—a practice common in the real business cycle literature. 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* (α). Data on factor shares may be found in social accounting matrices (e.g., see those from the Global Trade Analysis Project (GTAP) and the International Food Policy Research Institute). The GTAP5 database for Sub-Saharan Africa (SSA) suggests a capital share of 55–60% in the non-tradable sector and 35–40% in the tradable 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 sectors 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* ($R_{z,o}^i, \psi$). 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 projects from around 2001 found the median rate of return of 20% in SSA that varied from 15 to 29% for various subcategories of economic infrastructure investment. The macro-based estimates in Dalgaard and Hansen (2005) paint

TABLE 1. Calibration

Parameter	Value	Definition
κ	0.3400	Intertemporal elasticity of substitution in consumption
n_o	0.3600	Initial proportion of time used for non-leisure activities
ζ	1.1648	Preference parameter for leisure
α	0.4750	Capital's share in value added
R_z^i	0.2500	Initial return on economic infrastructure
ψ	0.1123	Elasticity of output with respect to economic infrastructure
R_z^e	0.4000	Initial return on schools
ϕ	0.5594	Elasticity of human capital accumulation with respect to schools
ν	0.5973	Elasticity of human capital accumulation with respect to private effort
χ	0.3863	Elasticity of effective units of labor with respect to human capital
δ_k, δ_e	0.0500	Depreciation rate of private physical and human capital
δ_z^i, δ_z^e	0.0500	Depreciation rate of public infrastructure and schools
g	0.015	Trend growth rate
r^d	0.1000	Initial real interest rate on domestic debt
r^k	0.1500	Initial gross return on capital
r^f	0.0400	Risk-free world real interest rate
r^x	0.0600	Initial real interest rate on public external borrowing
υ_g	0.0200	Public debt risk premium
η_g	0.0000	Public debt risk premium sensitivity parameter
b_o^d/y_o	0.2000	Initial public domestic debt to GDP ratio
b_o^x/y_o	0.0000	Initial public external debt to GDP ratio
$\mathcal{G}_o/y_o$	0.0400	Initial grants and other revenues to GDP ratio
g_o^i/y_o	0.0200	Initial capital investment in infrastructure to GDP ratio
g_o^e/y_o	0.0060	Initial capital investment in schools to GDP ratio
m_o^i/y_o	0.0200	Initial current expenditure on infrastructure to GDP ratio
m_o^e/y_o	0.0140	Initial current expenditure on schools to GDP ratio
γ_z^i	0.0650	Current expenditure on infrastructure as fraction of infrastructure stock
γ_z^e	0.1517	Current expenditure on schools as fraction of school stock
s^i	0.7692	Fraction of government capital expenditure going to infrastructure
τ_o	0.1500	Initial consumption VAT rate
$\mathcal{T}_o$	7.9376	Initial transfers to GDP ratio (as %)
λ	0.0000	Share of fiscal adjustment borne by transfers
$\rho_\tau, \rho_{\mathcal{T}}$	0.9900	Speed of adjustment of reference values for tax and transfers
$\lambda_{\tau,1}, \lambda_{\mathcal{T},1}$	0.2500	Fiscal policy reaction parameters for policy instruments
$\lambda_{\tau,2}, \lambda_{\mathcal{T},2}$	0.0200	Fiscal policy reaction parameters for debt

a similar picture with most estimates in 15–30% range for a wide array of different estimators. Some micro estimates from Foster and Briceño-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), Calderón et al. (2009), and Calderón and Servén (2010) supply additional evidence of

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high returns.[5] Thus, high returns appear to be the norm and we consider a high-return scenario as the base case by setting $R^i_{z,o} = 0.25$ at the initial equilibrium. Our initial values and parameters pin down ψ, which is found to be 0.1123.

- *Return to schools and parameters of the human capital accumulation process* ($R^e_{z,o}$, χ, ϕ, ν). Estimates on the macroeconomic return on education/schools are scant. However, it is frequently argued that, even after taking into account the inherent delays with which schools affect GDP, the return on public investment in schools is much higher than that on investment in roads—as a result of too little relative investment in schools in practice and a poor stock of human capital in LIDCs (as discussed in the Introduction). Acosta-Ormaechea and Morozumi (2017) and Bose et al. (2007) provide evidence consistent with this conventional wisdom and show that spending reallocations from roads to schools have growth-promoting effects and, importantly, these effects are significant only when a country's income level is low. In accordance with this evidence and to give as much leeway as possible to investment in schools, we assume a much higher return to schools. Accordingly, we set $R^e_{z,o} = 0.40$ in the initial equilibrium so that the government, without doubt, would make additional investment solely in schools in absence of distortions. We augment this baseline analysis with a sensitivity analysis for a range of differential in returns between roads and schools by varying $R^e_{z,o}$. As shown below, our results get stronger when this differential shrinks. In addition, we make an agnostic assumption that (the nonstationary counterparts of) the total factor productivity in both goods and human capital production, A^y and A^e, grow at the same rate g. Finally, we fix the proportion of non-leisure time devoted to schooling $\left(\frac{u_o}{n_o}\right)$ to 0.10 in the initial equilibrium. We impose these three restrictions and numerically work out the values of the three parameters governing our targets. This yields $\chi = 0.3863$, $\phi = 0.5594$, and $\nu = 0.5973$.
- *Depreciation rates* (δ_k, δ^e_z, δ^i_z, δ_e). Given the paucity of data on depreciation rates in LIDCs, we use a value of 5% for physical capital (private, roads, and schools), which is a typical value for the developed countries. Due to the lack of additional information, we also choose the same value for δ_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_o, r^k_o). 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 debt in accordance with the stylized facts. The real return of 15% on

private capital is a markup over the domestic real interest rate equal to the capital's depreciation rate. 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 ϱ is the subjective discount rate. With values of κ and g chosen above, the target for real interest rate yields the value of ϱ.

- *Risk-free world real interest rate, real interest rate of foreign borrowing, and debt risk premium parameters* $(r^f, r^x_o, \upsilon_g, \eta_g)$. We fix the world real interest rate at the 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 USA. In 2015, Angola and Gabon issued B+ rated eurobonds amounting to about US$1.5 billion and US$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_o in the initial equilibrium and, in turn, implies $\upsilon_g = 0.02$. Thus, the risk premium is set at 2%. While van der Ploeg and Venables (2011) provide a positive estimate $\eta_g = 1.89$, we keep the risk premium constant so that $\eta_g = 0$ as in practice it makes little difference for our results.
- *Public 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* $(\mathcal{G}_o)$. The grants are assumed to be 4% of GDP in the initial equilibrium, which is close to the average for LIDCs 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* $\left(\frac{g^i_o}{y_o}, \frac{g^e_o}{y_o}, \frac{m^i_o}{y_o}, \frac{m^e_o}{y_o}\right)$, *current expenditure on roads and schools as fraction of the stocks of roads and schools* $\left(\gamma^i_z, \gamma^e_z\right)$, and *fraction of government expenditure on roads* (ϖ^i). We set the initial total public expenditure on infrastructure (current and capital) to be equal to 6% of GDP, close to the LIDC SSA average of 6.09% for 2008 according to Briceño-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 LIDCs 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 for 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 $\left(\gamma_z^i, \gamma_z^e\right)$ follow in a straightforward manner from the initial ratios for capital investment and current spending on infrastructure and schools. In particular, $\gamma_z^i = 0.0650$ and $\gamma_z^e = 0.1517$. Finally, the fraction of government expenditures on roads (ϖ^i) turns out to be 76.92% in the initial equilibrium.

- *Consumption VAT* (τ_o). The consumption VAT rate 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 rate of 15.8% for LIDCs for 2005–2006 estimated from data by the International Bureau of Fiscal Documentation.
- *Net Transfers* ($\mathcal{T}_o$). At the initial steady state, transfers are set to ensure that the budget constraint of the government holds. This translates into $\mathcal{T}_o = 7.94\%$ of GDP. Given the definition of the other fiscal variables, this concept of transfers includes other taxes different from VAT as well as noncapital expenditures such as public wages.
- *Division of fiscal adjustment between expenditure cuts and tax increases* (λ). For the purpose of the simulations reported below, we assume that only taxes bear the burden of fiscal adjustment ($\lambda = 0$).
- *Speed of adjustment of reference values for computing the fiscal gap* (ρ_τ, $\rho_\mathcal{T}$). 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* ($\lambda_{\tau,1}, \lambda_{\tau,2}, \lambda_{\mathcal{T},1}, \lambda_{\mathcal{T},2}$). There are no estimates of these parameters for LIDCs. We set $\lambda_{\tau,1} = \lambda_{\mathcal{T},1} = 0.25$ and $\lambda_{\tau,2} = \lambda_{\mathcal{T},2} = 0.02$ to allow the government to finance a substantial part of the investment scale-up via debt. Sensitivity analysis is done for a range of tax reactivity.

The calibration above implies that there are diminishing returns to accumulable factors (public infrastructure, private physical capital, and human capital) in the technologies for both output ($\psi + \alpha + \chi(1-\alpha) < 1$) and human capital ($\phi + \chi\nu < 1$) and, therefore, growth along the balanced growth path is driven solely by exogenous growth at rate g in A^y and A^e.

With the calibration set forth above, we can solve the model both for its steady state and dynamics. Our calibration allows us to calculate values in the initial steady state for the variables that are exogenous to the model, namely, $\mathcal{G}_o$, g_o^z, and $(b^x + b^d)^{target} = b_o^x + b_o^d$. Given these values, the steady-state version of the model (with 33 equations in 33 variables as outlined at the end of Section 2) can be solved for the initial steady state. More generally, given an alternative set of values for these variables, one can solve for the corresponding steady state, for example, the final steady state. The same set of 33 equations can be solved for the transition given the initial state of the economy defined by k_0, e_0, b_0^d, b_0^x, z_0^i, z_0^e, and the paths for the exogenous variables. Our numerical simulations for the transition closely track the global nonlinear saddle path of the model. Thus, the solution is free of the errors that may be introduced by linearization. As there is no

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uncertainty in the model, the solution is based on perfect foresight. Moreover, as our experiments (described in following sections) involve at least one permanent change in policy, the economy converges to a different steady state than the initial one.[6]

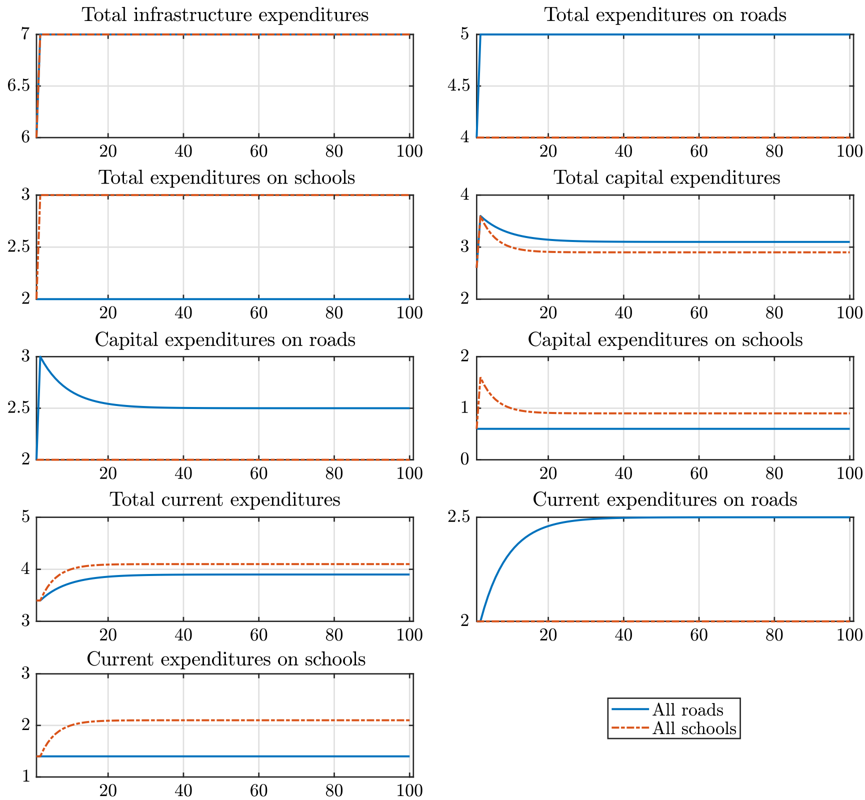
4. ROADS OR SCHOOLS: IMPLICATIONS FOR GROWTH AND DEBT SUSTAINABILITY

This section compares the effects of a public investment scale-up in roads and schools. We consider a permanent increase in combined public investment and current expenditure to the tune of 1% of initial GDP. Qualitative implications are, however, independent of the size of the scale-up. In particular, we focus on implications of external debt and, therefore, keep domestic debt fixed at the initial level in normalized terms, over time and across all experiments. This implies that it grows exogenously at rate g, the growth rate along the balanced growth path. Similarly, grants are also kept fixed at the initial level in normalized terms, over time and across all experiments. This fixed level of grants allows us to calibrate the model to a realistic level of distortionary taxation.

A permanent scale-up, that is, having a longer-term perspective in expenditure planning, is deemed 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.[7] This section shows the trade-offs between a scale-up of public investment exclusively in roads versus one that occurs entirely in schools. This exercise is intended to shed light on how a rise of investment in roads or schools individually affects the macroeconomic dynamics. In order to make the two cases comparable, we keep the increase in total government expenditure (including both capital and current expenditures) the same across the two cases. The optimal composition of the scale-up and its determinants are analyzed in Sections 5 and 6, respectively.

Given that the investment in schools has higher returns, it is expected to result in higher growth in the long run. At the same time, we show that some serious trade-offs arise during the transition. Qualitatively, the trade-off is fairly intuitive: while investment in schools is more attractive and would result in higher output in the longer run, as discussed in Section 2, 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. In Section 5, we show that the trade-off becomes more stringent when the return on schools is smaller, so our results hold *a fortiori* if the assumption of higher returns on schools is relaxed.

The intuition outlined above (and earlier while describing the model) is confirmed by the model simulations reported in Figures 2 and 3, where total government infrastructure expenditures rise from 6 to 7% of GDP. Figure 2 clarifies how the scale-up is apportioned to the various spending items. Let us first consider the scenario with the investment scale-up occurring entirely in roads.



Notes: Aggregate shock size: 1% of initial steady-state GDP; *x*-axes in years; *y*-axes in percent of initial steady-state GDP).

FIGURE 2. A permanent increase in public infrastructure: Current and capital expenditures associated with investing all in roads versus all in schools.

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 an 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 capital 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 the entire investment scale-up occurring in schools. Since maintaining schools requires proportionately larger current expenditure, in the long run, the split between capital and current expenditures is 30–70%, respectively (with capital expenditures increasing from 0.6 to 0.9% and current expenditures jumping from 1.4 to 2.1% of GDP).

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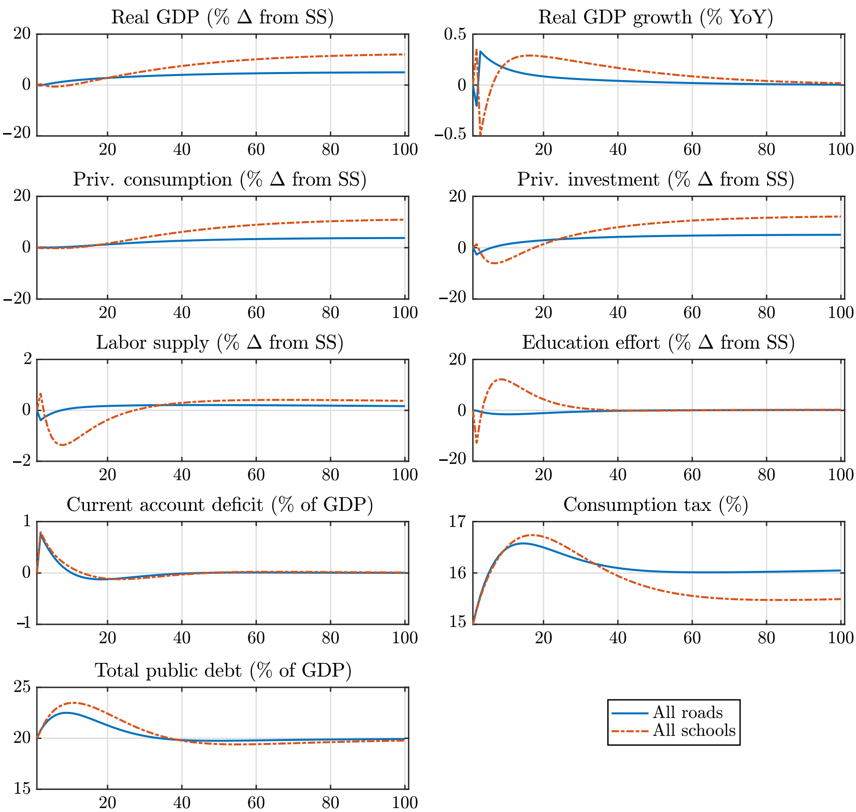

Notes: Aggregate shock size: 1% of initial steady-state GDP; *x*-axes in years; *y*-axes in percent deviations from initial steady state, unless otherwise indicated.

FIGURE 3. A permanent increase in public infrastructure: Effects on key macroeconomic variables associated with investing all in roads versus all in schools.

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 12% compared to a much smaller increase of 5% obtained with an exclusive investment in roads. Yet, for the first 9 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 6 years with investment in schools, whereas it stays above trend if the investment is made in roads. The initial disadvantage of investment in schools accumulates over time and it takes 20 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 difference 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 intertemporal substitution of labor toward the future, increasing the time households spend in schools in the first 20 years or so. Since output rises only slowly over time and agents cannot borrow from abroad, private investment falls in the medium run. In short, (relatively) lower output with investment in schools is matched by a (relatively) lower private investment demand with consumption responding marginally.

As the government ramps up investment, and consumption (its tax base) and revenues respond little on impact, the resulting fiscal deficit increases public debt.[8] 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 significantly. While public debt rises by about 1% of GDP for investment in roads, investment in schools results in a twofold increase of 2% of GDP.[9]

5. ROADS OR SCHOOLS: OPTIMAL COMPOSITION

The analysis in the previous section highlights the tension between investment in roads versus schools. One provides smaller—but immediate returns—with less challenges to debt sustainability, while the other results in larger gains far out into the future with associated risks to debt sustainability. Given that these two extreme scenarios provide such different profiles of benefits and costs, it may be useful to consider an intermediate scenario that can leverage strengths of both to deliver a better overall outcome.

We consider a government policy choosing a split of the scale-up of infrastructure between roads and schools such that households' welfare is maximized.

Figure 4 shows how households' welfare varies with the share of expenditure allocated to schools. The optimal share of educations is slightly below 75%. Considering the big advantage, in terms of rate of return, being given to schools in the baseline calibration, it is noteworthy that it is still optimal to devote more than 25% of the investment scale-up to roads. As seen above, the picture of an initially lower GDP growth associated with schools, together with the greater increase in public debt, and consequently in taxes, is reversed in the long run. This determines a dynamic trade-off which makes an interior share of schools in the investment scale-up welfare optimal.

In Figure 5, the corresponding equilibrium paths of macro variables are overlaid on the earlier two scenarios. The paths of the variables for the optimal composition are sandwiched between those of the two scenarios, yet closer to those for the scenario with all investment in schools given the high optimal share of schools.

All in all, the optimal composition of public investment into roads and schools improves welfare vis-a-vis investment entirely in schools by trading some of the

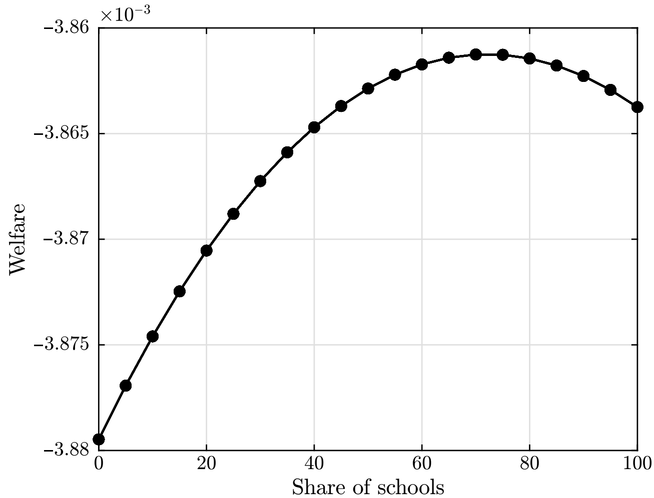

FIGURE 4. Share of schools in the public investment scale-up and associated welfare.

future welfare gains with those in the present. It also reduces (to a small extent) the distortionary effects of higher taxation and risks to debt sustainability, the former being implicitly accounted for in the welfare comparison.

6. KEY DETERMINANTS OF THE OPTIMAL INVESTMENT COMPOSITION

In this section, we examine how the optimal composition of public investment responds to a number of key determinants from a policy perspective. We begin by addressing one practical dimension alluded to earlier: the uncertainty regarding the differential between returns to roads and schools. We then address important considerations from the fiscal and political economy angles. First, given that investment in roads and schools may generate different responses for government debt, we analyze the impact of the policymakers' degree of debt intolerance on optimal investment composition. Second, we examine the role of political myopia. This last determinant turns out to be crucial given that investing in schools generates strikingly different profiles of gains in output, consumption, and ultimately welfare over the long run.

6.1. Return Differential

So far in our analysis, we have assumed a differential of 15% points in annual terms between the economic returns to schools and roads (namely the return is 25% for roads and 40% for schools). This baseline experiment was motivated by econometric evidence that returns to schools in developing countries may be very high in the long run (Bose et al. (2007); Acosta-Ormaechea and Morozumi (2017)). Notwithstanding this, the different macro-fiscal dynamics generated by

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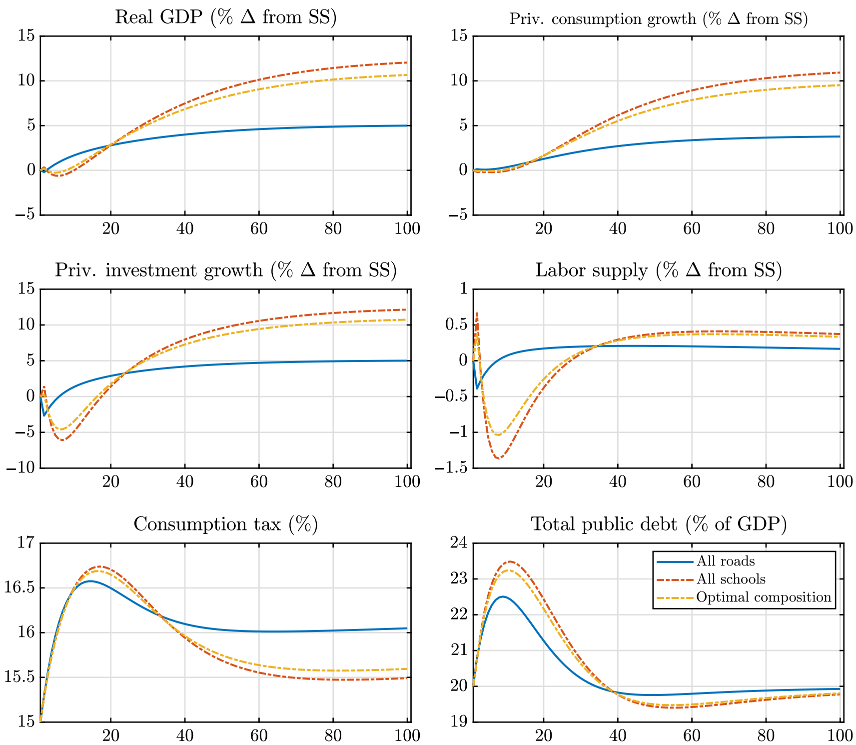

Notes: Aggregate shock size: 1% of initial steady-state GDP; *x*-axes in years; *y*-axes in percent deviations from initial steady state, unless otherwise indicated.

FIGURE 5. Effects of the optimal composition of the public investment scale-up on key macroeconomic variables.

investing in roads versus schools give rise to important trade-offs. Namely, it is optimal to devote a sizeable share of the investment scale-up to roads, even if schools are given such an advantage in terms of macroeconomic return.

These trade-offs become even more severe if the return differential between the two types of public investment becomes smaller.

Lower returns to schools—by rendering the dynamic trade-offs between the two types of investment more stringent—make the welfare-optimal share of schools in the public investment scale-up smaller. Figure 6(a) depicts the optimal share of schools as a function of the return to schools, keeping the return to roads fixed at 25%. When the return to schools drops from the baseline value of 40% to the same return of roads (25%), the optimal share of schools drops from around 75 to 10%. If the return to schools declines further, say to 23%, then schools' optimal share goes to zero.

The importance of analyzing the role of returns is twofold. On one hand, it clarifies that the results outlined in the previous section with a large return differential hold *a fortiori* when such a differential is narrower. On the other hand, it emphasizes that from the viewpoint of a benevolent welfare-optimizing social planner

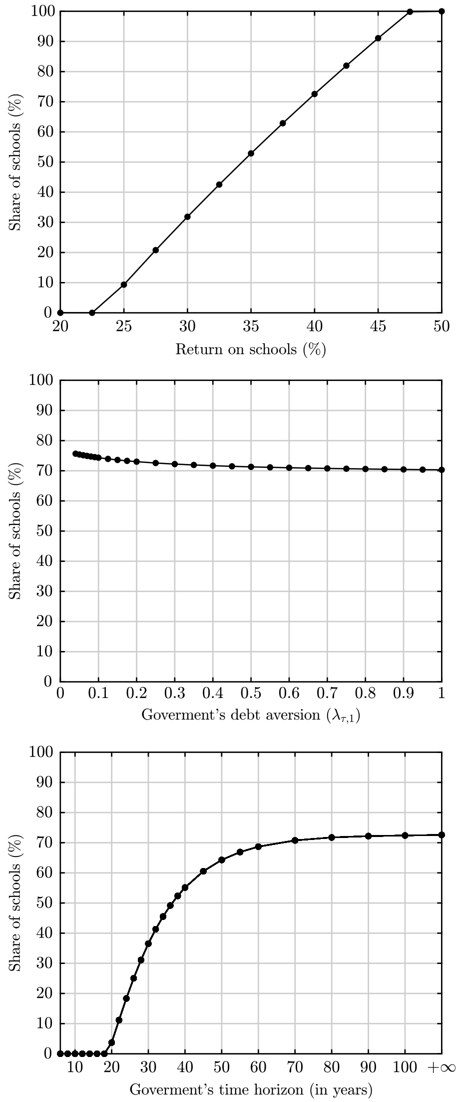

FIGURE 6. Optimal share of schools in the public investment scale-up: Key determinants. (a) Return to schools. (b) Debt intolerance. (c) Government's myopia.

with infinite time horizon, investing a share of the public investment scale-up in schools strongly depends on the expected return relative to other investments, and that a reasonably high return differential is required for a nontrivial share of investment to be optimally allocated to schools.

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6.2. Debt Intolerance

Governments in developing countries may often face considerable challenges in accessing international financial markets (see, e.g., Baldacci et al. (2013) and Gaspar et al. (2019)). High risk premia often make this operation costly and sometimes, even if countries are willing to bear these costs, they find issuing government bonds infeasible. This situation—often dubbed as debt intolerance (see, e.g., Reinhart et al. (2003))—may be the outcome of political instability, poor track record in meeting debt obligations, high macroeconomic volatility, and/or inability to mobilize tax revenues, which make buying debt instruments too risky in the eyes of foreign investors. Also for those countries with financial market access, the amount of external government debt they can accumulate, relative to the size of their economy, is typically well below the amount that can be accessed by advanced economies and some emerging markets. Moreover, resorting to domestic debt may not be desirable because it absorbs internal resources and leads to the crowding-out of nongovernmental domestic demand. The source of this financial constraint is of secondary importance for our analysis. To focus on its consequences, the severity of the financial constraint can be measured by the parameter $\lambda_{\tau,1} \in (0, 1]$: a higher value of the parameter corresponds to a larger share of the fiscal gap being covered by tax increases as opposed to external bond issuance; in the limit, when $\lambda_{\tau,1} = 1$, the government runs a balanced budget and no new debt is issued at all.

Figure 6(b) reports the optimal share of schools in the investment scale-up as a function of $\lambda_{\tau,1}$. The main result is that debt intolerance makes it less optimal to invest in schools, although the effect is small from a quantitative viewpoint. The explanation for the direction of the relationship is intuitive, since investing in schools results in a more pronounced spike in government debt. Under the baseline returns the optimal share of schools goes from almost 80%, when the government resorts almost entirely to debt (and taxes are used minimally, just enough to prevent public debt from exploding), to under 70% when the government resorts entirely to taxes. In the limiting case of complete absence of debt intolerance ($\lambda_{\tau,1} \to 0$), the government would invest entirely in schools given the large return differential. However, public debt would grow unboundedly.

Analyzing debt intolerance in this context is important because it emphasizes one of the challenges that poor economies face in investing in schools (versus roads): economic returns on schools take longer to materialize and require more financial resources in the initial phases of the investment program. Absent access to external financing, higher distortionary taxation—*ceteris paribus*—makes it optimal to devote a smaller fraction of the investment scale-up to schools. This also underscores the role of international cooperation. By mitigating this financial friction via concessional financing and grants, multilateral organizations can have an important role in helping governments achieve higher social spending targets.

6.3. Political Myopia

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 selfish political leaders distort the provision of public goods to enhance their chances of getting reelected (see Aidt and Dutta (2007); Bonfiglioli and Gancia (2013)). In the macroeconomic literature, efforts have been made on how to model agents' myopia. For instance, Angeletos and Huo (2018), who build on Angeletos and Lian (2018) and Morris and Shin (2006), model myopia as extra discounting of future outcomes. In this section, we allow for policymakers' myopia to introduce political considerations into the model and shed light on how such practical realities may affect the optimal composition of the public investment scale-up in roads and schools.

We model the adverse impact of political leaders' desire for getting reelected as their myopia in evaluating the benefits of various policies beyond a certain time frame. This can be rationalized in the case of asymmetric information between voters and politicians, with voters using current GDP growth as a signal to evaluate politicians when reelecting them. Therefore, while fully selfless (or altruistic) policymakers would plan over an infinite time horizon, a myopic planner disregards the benefits of policies that arise after a certain time horizon. The greater the selfishness, the higher the political myopia and therefore the shorter the time horizon the policymaker values. It must be emphasized that a political incumbent's time horizon (for evaluating benefits) is not necessarily the same as the duration of their incumbency. The former will be typically longer than the latter, reflecting the forward-looking behavior of the people who elect them. Specifically, if the constituents care about the effects of policies of leaders beyond the duration for which they hold office, it will be rational for the leaders to also lengthen their time horizon for the policy design and the evaluation of policy choices to increase their chances of being reelected. A similar outcome would also be obtained if leaders cared about their legacy. The ranking of policies is still based on agents' discounted utility, yet summed over limited time horizons to capture leaders' myopia.

In Figure 6(c), we plot the welfare-maximizing share of schools in the public investment scale-up as a function of the social planner's time horizon. A planner with an horizon of less than 20 years would not invest at all in schools. A longer time horizon of 50 years is needed to take a myopic leader's desired share close to that of a completely altruistic social planner with infinite horizon. Political myopia is an important consideration for developing countries since it helps justify the preference for quicker gains obtained with investing in roads. The argument for investing in schools requires a far-reaching vision that goes at least beyond one generation.

7. CONCLUSIONS

There is a large literature on the macroeconomic effects of public investment, yet most of this literature abstracts from its composition. We investigate this policy choice from the perspective of roads versus schools to address the following question: Why do governments in developing economies favor roads rather than schools in public investment scale-ups?

We show that some governments' apparent failure to invest more in schools could be rationalized in a model with a detailed specification of fiscal policy that includes distortionary taxation and government debt. The different pace at which roads and schools contribute to economic growth is central to this optimal allocation decision. The combined dynamics of both front-loaded fiscal costs of investments and a slow accrual of growth benefits from investing in schools—albeit larger in the long run—do not square well with a macro-fiscal regime with distortionary taxation and government debt. Besides these genuine concerns, policymakers' myopia turns out to be a powerful explanation for the observed lower shares of schools at the margin.

Multilateral agencies could alleviate these concerns and encourage policymakers in developing countries to undertake long-term investment in schools by providing tied concessional financing and grants. While tying aid to investment in schools would address the issue of myopia, concessional terms would mitigate concerns of debt intolerance.

The incentives to alleviate these concerns would become even stronger if another major component of social infrastructure, namely health, was also taken into consideration. While the exact dynamic response to investment in health infrastructure (hospitals) would differ, similar trade-offs would operate vis-a-vis investment in roads. We leave the task of carrying out this analysis for future research.

NOTES

1. To our knowledge, Hall and Jones (1999) were the first to define the concept of "social infrastructure."

2. There is one exception that is discussed later.

3. Some contributions have emphasized that, especially in developing economies, investment spending can be inefficient and typically a significant fraction does not translate into public capital (see, e.g., Pritchett (2000) and Dabla-Norris et al. (2012)). While some papers (see, e.g., Buffie et al. (2012)) incorporate public investment inefficiencies in the model, here we abstract from this additional feature because such considerations would apply symmetrically to both social and economic investment and our goal is to emphasize their distinguishing features.

4. We can manipulate (22) as $r_t^x = r^f + \upsilon_g e^{\eta_g \left(\frac{b_t^x}{y_t} - \frac{b_O^x}{y_O} \right)} = r^f + \upsilon_g e^{-\eta_g \frac{b_O^x}{y_O}} e^{\eta_g \frac{b_t^x}{y_t}} = r^f + \widetilde{\upsilon}_g e^{\eta_g \frac{b_t^x}{y_t}}$, to obtain an alternative functional form, which only changes the calibrated value of parameter υ_g, denoted as $\widetilde{\upsilon}_g$. This shows that the interest rate for any level of borrowing is independent of the initial bond position.

5. For 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).

6. While a number of tools are available to solve such dynamic models with perfect foresight, our numerical simulations are generated using a set of programs written in Matlab and Dynare (see https://www.dynare.org/).

7. To be specific, as the economy grows at rate g, a permanent increase of 1% of initial GDP in normalized terms implies that the expenditure also grows over time at the same rate.

8. Since we consider the case in which the government finances deficits only via international borrowing, the increase is in public external debt.

9. If the model featured an income/output-based tax instead of a consumption-based tax, the differences would be larger because output differences are much larger across the two scenarios than consumption differences. Putting it differently, relative to income-based taxation, consumption-based taxation reduces the disadvantage of investment in schools in terms of debt sustainability implications.

REFERENCES

Abiad, A., D. Furceri and P. Topalova (2015) The Macroeconomic Effects of Public Investment: Evidence from Advanced Economies. IMF Working Paper: No. 15/95.

Acosta-Ormaechea, S. and A. Morozumi (2017) Public spending reallocations and economic growth across difference income levels. *Economic Inquiry* 55(1), 98–114.

Adam, C. and D. Bevan (2006) Aid and the supply side: Public investment, export performance, and dutch disease in low-income countries. *The World Bank Economic Review* 20(2), 261–290.

Adam, C. and D. Bevan (2014) Public Investment, Public Finance, and Growth: The Impact of Distortionary Taxation, Recurrent Costs, and Incomplete Appropriability. IMF Working Paper: No. 14/73.

Aidt T. and J. Dutta (2007) Political myopia and economic growth. *European Journal of Political Economy* 23(3), 734–753.

Agenor, P.-R. and P. Montiel (1999) *Development Macroeconomics,* 2nd ed. Princeton, N.J.; Princeton University Press.

Agenor, P.-R. (2010) A Theory of infrastructure-led development. *Journal of Economic Dynamics and Control* 34(5), 932–950.

Andreolli, M. and A. Abdychev (2016) Investing in Electricity, Growth, and Debt Sustainability: The Case of Lesotho. IMF Working Paper: No. 16/115.

Angeletos, G.-M. and Z. Huo (2018) Myopia and Anchoring, NBER Working Papers 24545, National Bureau of Economic Research.

Angeletos, G.-M. and C. Lian (2018) Forward guidance without common knowledge. *American Economic Review* 108(9), 2477–2512.

Araujo, J.D., B. Li, M. Poplawski-Ribeiro and L.-F. Zanna (2016) Current account norms in natural resource rich and capital scarce economies. *Journal of Development Economics* 120(May), 144–156,

Arnone, M. and A. Presbitero (2010) *Debt Relief Initiatives: Policy Design and Outcomes*. Routledge.

Baldacci, E., S. Dell' Erba and T. Poghosyan (2013) Spatial spillovers in emerging markets spreads. *Empirical Economics* 45(2), 735–756.

Barro, R. (1990) Government spending in a simple model of endogenous growth. *Journal of Political Economy* 98(S5), 103–125.

Barro, R. and X. Sala-i-Martin (1992) Convergence. *Journal of Political Economy* 100(2), 223–251.

Berg, A., T. Mirzoev, R. Portillo and L.-F. Zanna (2010a) The Short-Run Macroeconomics of Aid Inflows: Understanding the Interaction of Fiscal and Reserve Policy. IMF Working Paper: No. 10/65.

Berg, A., J. Gottschalk, R. Portillo and L.-F. Zanna (2010b) The Macroeconomics of Medium-Term Aid Scaling-Up Scenarios. IMF Working Paper: No. 10/160.

Briceño-Garmendia, C., K. Smits and V. Foster (2008) Financing Public Infrastructure in Sub-Saharan Africa: Patterns and Emerging Issues. AICD Background Paper 15 (World Bank).

Bonfiglioli A. and G. Gancia (2013) Uncertainty, electoral incentives and political myopia. *Economic Journal* 123(568), 373–400.

Bose, N., M. E. Haque and D. R. Osborne (2007) Public expenditure and economic growth: A disaggregated analysis for developing countries. *The Manchester School* 75(5), 533–556.

Buffie, E., A. Berg, C. Pattillo, R. Portillo and L.-F. Zanna (2012) Public Investment, Growth, and Debt Sustainability: Putting Together the Pieces. IMF Working Paper: No. 12/144.

Calderón, C., E. Moral-Benito and L. Servén (2009) Is Infrastructure Capital Productive? A Dynamic Heterogeneous Approach. Mimeo (World Bank).

Calderón, C. and L. Servén (2010) Infrastructure in Latin America. Policy Research Working Paper: No. 5317 (World Bank).

Cerra, V., S. Tekin and S. Turnovsky (2008) Foreign Aid and Real Exchange Rate Adjustments in a Financially Constrained Dependent Economy. IMF Working Paper: No. 08/204.

Chatterjee, S. and S. Turnovsky (2007) Foreign aid and economic growth: The role of flexible labor supply. *Journal of Development Economics* 84(1), 507–533.

Dabla-Norris, E., A. K. Brumby, Z. Mills and C. Papageorgiou (2012) Investing in public investment: An index of public investment efficiency. *Journal of Economic Growth* 17(3), 235–266.

Dalgaard, C. and H. Hansen (2005) The Return to Foreign Aid. Discussion Paper No. 05-04, Institute of Economics, University of Copenhagen.

Devarajan, S., V. Swaroop and H. Zou (1996) The composition of public expenditure and economic growth. *Journal of Monetary Economics* 37(2), 313–344.

Escribano, A., J. Guasch and J. Pena (2008) Impact of Infrastructure Constraints on Firm Productivity in Africa. AICD Working Paper: No. 9 (World Bank).

Fedelino, A. and A. Kudina (2003) Fiscal Sustainability in African HIPC Countries: A Policy Dilemma? IMF Working Paper: No. 03/187.

Foster, V. and C. Briceño-Garmendia (2010) Africa's Infrastructure: A Time for Transformation, forthcoming (Agence Francaise de Developpement and the World Bank).

Futagami, K., Y. Morita and A. Shibata (1993) Dynamic analysis of an endogenous growth model with public capital. *Scandinavian Journal of Economics* 95(4), 607–625.

Gaspar, V., D. Amaglobeli, M. Garcia-Escribano, D. Prady and M. Soto (2019) Fiscal Policy and Development: Human, Social, and Physical Investments for the SDGs, IMF Staff Discussion Notes No. 19/03.

Ghazanchyan, M., R. Marto, J. Jonas and K. Douglass (2017) Collect More, Spend Better: Public Investment in Asian Frontier Markets, IMF Working Paper: No. 17/10.

Glomm, G. and B. Ravikumar (1994) Public investment in infrastructure in a simple growth model. *Journal of Economic Dynamics and Control* 18(6), 1173–1187.

Gueye, C. and A. Sy (2010) Beyond Aid: How Much Should African Countries Pay to Borrow? IMF Working Paper: No. 10/140.

Hall, R. and C. Jones (1999) Why do some countries produce so much more output per worker than others? *The Quarterly Journal of Economics* 144(1), 83–116.

Heller, P. S. (1991) Operations and Maintenance, IMF Public Expenditure Handbook. (International Monetary Fund).

Hulten, C., E. Bennathan and S. Srinivasan (2006) Infrastructure, externalities, and economic development: A study of Indian manufacturing industry. *World Bank Economic Review* 20(2), 291–308.

International Monetary Fund (2009) Changing Patterns in Low-Income Country Financing and Implications for Fund Policies on External Financing and Debt, SM/09/56.

International Monetary Fund (2014) *World Economic Outlook: Legacies, Clouds, Uncertainties*, Chapter 3. Washington, DC: International Monetary Fund.

International Monetary Fund (2016a) Djibouti: Selected Issues, IMF Country Report No. 16/249.

International Monetary Fund (2016b) Maldives: Staff R debt a version eport for the 2016 Article IV Consultation, IMF Country Report No. 16/135.

King, R., C. Plosser and S. Rebelo (1988) Production, growth, and business cycles:1. The basic neoclassical model. *Journal of Monetary Economics* 21(2–3), 195–232. North-Holland.

Leeper, E. M., T. B. Walker and S.-C. S. Yang (2010) Government investment and fiscal stimulus. *Journal of Monetary Economics* 57(8), 1000–1012.

Melina, G., S. Yang and L.-F. Zanna (2016) Debt sustainability, public investment, and natural resources in developing countries: The DIGNAR model. *Economic Modelling* 52, 630–649, Elsevier.

Morris, S. and H. S. Shin (2006) Inertia of forward-looking expectations. *American Economic Review* 96(2), 152–157.

Ogaki, M., J. Ostry and C. Reinhart (1996) Saving behavior in low- and middle-income developing countries. *IMF Staff Papers* 43, 38–71.

Panizza, U. (2008) Domestic and External Public Debt in Developing Countries. UNCTAD Discussion Paper: No. 188.

Perrault, J., L. Savard and A. Estache (2010) The Impact of Infrastructure Spending in Sub-Saharan Africa: A CGE Modeling Approach. Policy Research Working Paper: No. 5386 (World Bank).

Pritchett, L. (2000) The tyranny of concepts: CUDIE (Cumulated, Depreciated, Investment Effort) is not capital. *Journal of Economic Growth* 5(4), 361–384.

Reinhart, C. M., K. Rogoff and M. A. Savastano (2003) Debt intolerance. *Brookings Papers on Economic Activity* 34 (2003–1), 1–74.

Rosenstein-Rodan, P. (1943) Problems of industrialization of eastern and southeastern europe. *Economic Journal* 53(210–211), 210–211.

Schmitt-Grohe, S. and M. Uribe (2003) Closing small open economy models? *Journal of International Economics*, 61, 163–185.

Straub, S. (2008) Infrastructure and Growth in Developing Countries: Recent Advances and Research Challenges. Policy Research Working Paper: No. 4460 (World Bank).

Thurlow, J., X. Diao and C. McCool (2008) 2004 Social Accounting Matrix: Malawi. International Food Policy Research Institute.

Thurlow, J., D. Evans and S. Robinson (2004) A 2001 Social Accounting Matrix for Zambia. International Food Policy Research Institute (Washington, D.C.)

van der Ploeg, F. and A. Venables (2011) Harnessing windfall revenues: Optimal policies for resource-rich developing economies. *Economic Journal* 121(551), 1–30.

Zanna L.-F., E. F. Buffie, R. Portillo, A. Berg and C. Pattillo (2019) Borrowing for growth: Big pushes and debt sustainability in low-income countries. *World Bank Economic Review* 33(3), 661–689.