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The composition of government spending and growth: is current or capital spending better?

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In an endogenous growth framework with two public goods with differing productivities, this paper analytically characterizes optimal fiscal policy for a decentralized economy, whereby the optimal values of the growth rate, tax rate and expenditure shares on the two public goods are linked directly to their productivity parameters. Using panel data for 15 developing countries over 28 years, we show using GMM techniques, that current (capital) spending has positive (negative) and significant effects on the growth rate, contrary to commonly held views. For instance, spending on operations and maintenance has a stronger impact on growth than both health and education spending. We consider the various components on the revenue side of the government budget constraint to take into account possible omitted variable bias that could arise if tax revenue alone was considered.

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1. Introduction

It is well-understood in the endogenous growth literature that fiscal policy has potentially important effects on the long-run growth rate of the economy. In this context, the impact of productive government spending on growth becomes important. In a seminal paper, Barro (1990) models this in terms of public services—a flow variable—being in the economy's production function. Futagami *et al.* (1993) introduce public capital—a stock variable—instead, and this is sufficient to give rise to transitional dynamics. Also in an endogenous growth framework, Ghosh and Roy (2004) introduce both public capital and public services as inputs in the production of the final good, and demonstrate that optimal fiscal policy in an economy depends not only on the tax rate but also on the apportionment of tax revenues between the accumulation of public capital and the provision of public services. The relationship between the composition of government expenditure and growth is investigated by Devarajan *et al.* (1996) as well. They consider two productive services (i.e., both flow variables)[1] in a CES production function in their theoretical model—one more productive than another—and derive the important result that a shift in favour of an 'objectively' more productive type of expenditure may not raise the growth rate if its initial share is 'too high'. They also try to determine empirically, which components of public expenditure are more productive in developing countries and find, somewhat surprisingly, that an increase in the share of current—rather than capital—expenditure has positive and statistically significant growth effects.

Devarajan *et al.* (1996) suggest that an attempt to study optimal fiscal policy, instead of taking the government's decisions as given, could be a 'fruitful extension' of their paper. This is exactly what we attempt to do in this paper.[2] Within a decentralized economy set-up, we characterize the welfare-maximizing fiscal policy for a benevolent government (i.e., the second-best outcome), which chooses the fiscal instruments at its disposal to maximize the representative agent's utility.[3] Our model solves for the three key endogenous variables, the optimal expenditure shares of the two services, the optimal tax rate, and the optimal growth rate in terms of the key technological and behavioural parameters of the model.[4] We then try to determine from the data on capital and current public spending (which are commonly perceived as being more and less productive respectively), whether the actual growth performance of a sample of developing countries shows that fiscal policies have been pursued in an optimal manner, and whether capital or current spending ought to be interpreted as the more productive component of public expenditure from an optimal fiscal policy perspective.[5]

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[1] This is how this model differs from Ghosh and Roy (2004).

[2] A recent theoretical paper by Chen (2006) in this journal considers an endogenous growth model where the benevolent government chooses the optimal composition of spending. This optimal spending composition is determined by all policy and other structural parameters, which raise the marginal utility of private relative to public consumption, thereby inducing public investment and increasing growth. Although that paper deals with the optimal spending composition, it is different from ours because government consumption spending is in the utility function and government production spending is in the production function. Also, unlike us, the tax rate is exogenously given.

[3] In Appendix 1, we derive the social optimum, i.e., first-best outcome, as an ideal (if unrealistic) benchmark, where the social planner—in contrast to the benevolent government in a decentralized economy—chooses private consumption and private investment for the agent in addition to choosing the fiscal instruments, τ, g_1 and g_2.

[4] Thus, while in the Devarajan *et al.* (1996) model, the economy's growth rate is expressed in terms of the tax rate and expenditure shares, which are both exogenous (eq. (7)); in our extension of their model, the optimal growth rate is expressed in terms of optimal values of those two variables (eq. (18)).

[5] In terms of econometric methodology, we attempt to capture fiscal policy where the tax rate and expenditure shares are not chosen optimally, by the OLS and GMM single equation technique, and optimal fiscal policy (where the key variables are jointly determined) through the GMM system. This distinguishes our empirical analysis from that of Devarajan *et al.* (1996).

Our empirical results clearly show that current—rather than capital—spending has contributed to growth, and in this sense, our results conform to Devarajan *et al.* (1996). Having determined that current rather than capital spending has proved more productive, we then investigate whether certain functional components within the two categories of spending contribute to growth. To this end, we pick out expenditure on health and education out of capital spending, and expenditure on operations and maintenance (O&M) out of current spending to verify whether these individually contribute to growth. Our results show that both health and educational spending have a negative and significant effect on growth (which concurs with Devarajan *et al.* (1996)), while the O&M spending component has a positive and significant impact on growth.

Next, in Section 5, we incorporate within the government budget constraint, the most important revenue-side variables, like tax revenue, non-tax revenue and the budget deficit/surplus. Here, we follow the methodology outlined by Kneller *et al.* (1999) and adopted by, among others, Adam and Bevan (2005) and Bose *et al.* (2007). This ought to take into account the possible omitted variable bias that could be present in models that concentrate on the expenditure side of the government budget constraint, such as the Devarajan *et al.* (1996) framework. Our empirical results show that capital and current expenditure continue to exert negative and positive effects respectively, on growth, as before. On the revenue side, tax and non-tax revenue have positive and significant effects on the growth rate, while the effect of the budget deficit/surplus does not turn out to be statistically significant.

Devarajan *et al.* (1996) link this result to their theoretical model in suggesting that 'expenditures which are normally considered productive could become unproductive if there is an excessive amount of them', and capital spending in developing countries may have squeezed current spending at the margin. But given that current spending as a proportion of GDP has typically been above 17% in contrast to capital spending as a ratio of GDP, which has been below 3% in our sample of 15 countries over 1972–99 (even allowing for the possibility that diminishing returns may set in early for capital goods)—and the values are quite similar for the sample of countries chosen by Devarajan *et al.* (1996)—the way the authors have linked their empirical results to their analytical model seems somewhat unconvincing. From an optimal fiscal policy perspective, one can argue that countries which have correctly perceived current spending as being the more productive have increased the share of spending on this category of public goods, and this has led to higher growth, and countries that have not done this have lost out.

It is also quite likely that countries that have allocated funds towards capital spending and away from current spending have often done so for reasons other than productivity considerations, and this is where the role of corruption assumes importance. As Tanzi and Davoodi (1997) have noted, private enterprises often get contracts for large public investment projects by paying a hefty 'commission' to government officials. This shows that capital spending is highly discretionary, and the same is not true for current spending, which generally reflects spending on previous commitments (for example, wages, salaries, pensions, subsidies), thus allowing limited discretion in the short-run to politicians.

The rest of the paper is organized as follows. Section 2 sets up the theoretical model under a balanced budget framework, and derives the analytical results under optimal fiscal policy. Section 3 discusses the data, specifies the econometric model and methodology, and reports the empirical estimates. In Section 4, robustness tests are carried out on (i) sub-samples of countries with respect to GDP, and (ii) some functional components of government expenditure. In Section 5, we extend the framework to include the revenue side of the government budget constraint more fully. Section 6 links the theoretical results with the empirical analysis. Finally, Section 7 concludes.

2. The analytical framework

2.1 Optimal fiscal policy

In this section we first write down the key equations of the Devarajan *et al.* (1996) model, and then characterize the optimal fiscal policy (henceforth abbreviated as OFP) of the government. The authors consider a CES technology (where y is output, k is private capital, and g_1, g_2 are two types of government spending), which is given by

$$y = [\alpha k^{-\zeta} + \beta g_1^{-\zeta} + \gamma g_2^{-\zeta}]^{-1/\zeta}, \tag{1}$$

where $\alpha > 0$, $\beta \geqslant 0$, $\gamma \geqslant 0$, $\alpha + \beta + \gamma = 1$, $\zeta \geqslant -1$.

The government's budget constraint is

$$g_1 + g_2 = \tau y, \tag{2}$$

where τ is the (constant over time) income tax rate.

The shares of government expenditure that go toward g_1 (ϕ) and g_2 ($1-\phi$) are given by

$$g_1 = \phi \tau y \ \ and \ \ g_2 = (1-\phi)\tau y, \tag{3}$$

where $0 \leqslant \phi \leqslant 1$.

The representative agent's utility function is isoelastic, and utility is derived from private consumption (c), and is given by

$$U = \int_0^\infty \frac{c^{1-\sigma} - 1}{1-\sigma} e^{-\rho t} dt \tag{4}$$

where ρ (> 0) is the rate of time preference.

The agent's budget constraint is

$$\dot{k} = (1-\tau)y - c. \tag{5}$$

Devarajan *et al.* (1996) derive an expression for the ratio, g/k, given by

$$\frac{g}{k} = \left[\frac{\tau^{\zeta} - \beta\phi^{-\zeta} - \gamma(1-\phi)^{-\zeta}}{\alpha}\right]^{1/\zeta}, \tag{6}$$

and of the economy's (endogenous) growth rate, λ, given by

$$\lambda = \frac{\alpha(1-\tau)\{\alpha\tau^{\zeta}/[\tau^{\zeta}-\beta\phi^{-\zeta}-\gamma(1-\phi)^{-\zeta}]\}^{-(1+\zeta)/\zeta}-\rho}{\sigma}. \tag{7}$$

Our task is to characterize OFP in this model. We take eqs (1)–(5) as being given exactly as in Devarajan *et al.* (1996). The representative agent's problem is to choose c and $\dot{k}$ to maximize utility—which is U in (4)—subject to (5), taking τ, g_1 and g_2, and also k_0 as given. The first order conditions give rise to the Euler equation:

$$\lambda \equiv \frac{\dot{c}}{c} = (1-\tau)\frac{\partial y}{\partial k} - \rho. \tag{8}$$

The objective of the government in a decentralized economy is to run the public sector in the nation's interest, taking the private sector's choices as given.[6] In other words, the government's problem is to choose τ, g_1 and g_2 to maximize the representative agent's utility subject to (2), (5), and (8), taking k_0 as given. The first order conditions with respect to τ, g_1, and g_2 respectively yield $\partial y/\partial g_1 = \partial y/\partial g_2 = 1$, from which we can obtain the optimal ratio of the two public goods when we have a benevolent government:

$$\left(\frac{g_1}{g_2}\right)^{*} = \left(\frac{\beta}{\gamma}\right)^{\frac{1}{\zeta+1}}. \tag{9}$$

The value of g/k is given in (6) above. Hence, using (9), we can obtain the individual values of g_1/k and g_2/k:

$$\frac{g_1}{k} = \left[\frac{(\beta/\gamma)^{(1/(\zeta+1))}}{(\beta/\gamma)^{(1/(\zeta+1))}+1}\right].\left[\frac{\tau^{\zeta}-\beta\phi^{-\zeta}-\gamma(1-\phi)^{-\zeta}}{\alpha}\right]^{1/\zeta}, \tag{10}$$

$$\frac{g_2}{k} = \left[\frac{1}{(\beta/\gamma)^{(1/(\zeta+1))}+1}\right].\left[\frac{\tau^{\zeta}-\beta\phi^{-\zeta}-\gamma(1-\phi)^{-\zeta}}{\alpha}\right]^{1/\zeta}. \tag{11}$$

From $\partial y/\partial g_1 = 1$, we obtain

$$g_1^{*} = \beta^{\frac{1}{1+\zeta}}.y, \tag{12}$$

and from $\partial y/\partial g_2 = 1$, we obtain

$$g_2^{*} = \gamma^{\frac{1}{1+\zeta}}.y. \tag{13}$$

We are now in a position to find an expression for the optimal tax rate for the decentralized economy under a benevolent government. From the government

[6] See Bruce and Turnovsky (1999), p.174–6, for a characterization of optimal and 'second-best' optimal fiscal policies for an economy on its balanced growth path. See also Sarte and Soares (2003, p.41).

budget constraint given by (2), and given the optimal shares (of output) of the two productive inputs given by (12) and (13) above, the optimal tax rate is given by

$$\tau^* = \beta^{\frac{1}{\zeta+1}} + \gamma^{\frac{1}{\zeta+1}}. \tag{14}$$

Finally, the optimal share of the first public service from a welfare-maximizing point of view is obtained by combining equations (3), (12), and (14):

$$\phi^* = \frac{\beta^{1/(\zeta+1)}}{\beta^{1/(\zeta+1)} + \gamma^{1/(\zeta+1)}}. \tag{15}$$

Clearly then, the optimal share of the second public service is obtained by combining equations (3), (13), and (14):

$$1 - \phi^* = \frac{\gamma^{1/(\zeta+1)}}{\beta^{1/(\zeta+1)} + \gamma^{1/(\zeta+1)}}. \tag{16}$$

Combining (9), (15), and (16), we obtain the following equation:

$$\left(\frac{g_1}{g_2}\right)^* = \frac{\phi^*}{1-\phi^*} = \left(\frac{\beta}{\gamma}\right)^{\frac{1}{\zeta+1}}. \tag{17}$$

Finally, one can derive an expression for the growth rate that could be achieved in an economy where a benevolent government chooses its fiscal instruments, τ, g_1, and g_2, to maximize the welfare of the representative agent. This optimal growth rate expression can be obtained by combining eq. (7) with eqs (14), (15), and (16), and is given by

$$\begin{aligned}\lambda^* &= \frac{\alpha(1-\tau^*)\{\alpha\tau^{*\zeta}/[\tau^{*\zeta} - \beta\phi^{*-\zeta} - \gamma(1-\phi^*)^{-\zeta}]\}^{-(1+\zeta)/\zeta} - \rho}{\sigma} \\ &= \frac{\alpha^{-1/\zeta}[1 - \beta^{1/(\zeta+1)} - \gamma^{1/(\zeta+1)}]^{(1+2\zeta)/\zeta} - \rho}{\sigma}.\end{aligned} \tag{18}$$

We have thus analytically characterized optimal fiscal policy in the Devarajan *et al.* (1996) model. As is clear from eqs (14)–(18) above, we obtain closed-form solutions to all the important fiscal variables in terms of the key technological and behavioural parameters of the model. So, there are interesting implications for policy when we consider the case where the government formulates fiscal policy with a view to maximizing the welfare of the representative agent, rather than taking as 'given' the tax rate and expenditure shares on the two public goods.

2.2 Comparative statics

In this section we study how the key variables: the optimal growth rate (λ^*), the optimal tax rate (τ^*), and the ratio of the optimal shares of the two public services, ($\phi^*/(1-\phi^*)$), respond to a change in the productivity parameter, β, where β is the share in the production function of the (*a priori*) more productive public good ($\beta > \gamma$).

First, from eq. (18), we find $d\lambda^*/d\beta$:

$$\frac{d\lambda^*}{d\beta} = A.B, \ \textit{where} \ A \equiv \frac{1}{\sigma}.\frac{\alpha^{-1/\zeta}}{1+\zeta}.\left(\frac{1+2\zeta}{\zeta}\right)\left[1-\beta^{1/(1+\zeta)}-\gamma^{1/(1+\zeta)}\right]^{(1+\zeta)/\zeta}, \tag{19}$$

$B \equiv \gamma^{-\zeta/(1+\zeta)} - \beta^{-\zeta/(1+\zeta)}$.

Clearly, $d\lambda^*/d\beta > 0$ *if* $\beta > \gamma$.

If $\beta = \gamma$ (the two components of public spending are equally productive), then a rise in β at the margin does not affect the optimal growth rate. But if one component (g_1) is more productive than another (g_2), then an increase in the productivity of that input (β, which is the share of g_1 in the production function) will raise the growth rate. So it is important to identify which in reality is the more productive input, as an increase in its share in the production function would bolster growth. Conversely, an increase in the share of the less productive input in the production function will have an adverse effect on growth.[7]

Next, from eq. (14), we find $d\tau^*/d\beta$:

$$\frac{d\tau^*}{d\beta} = \frac{1}{1+\zeta}\left[\frac{1}{\beta^{\zeta/(1+\zeta)}} - \frac{1}{\gamma^{\zeta/(1+\zeta)}}\right] \tag{20}$$

Clearly, $d\tau^*/d\beta < 0$ *if* $\beta > \gamma$.

Again, if $\beta = \gamma$, the marginal effect of an increase in the productivity of one of the public goods will not make a difference to how the optimal tax rate behaves. However, if $\beta > \gamma$, then an increase in the share of the more productive input in the production function will reduce the optimal tax rate because the higher productivity translates into higher output, and this will generate higher tax revenues, which thereby requires a lower tax rate to balance the government budget. So, from a welfare-maximizing perspective, an increase in the productivity of the more productive public good leads to a fall in the optimal tax rate.

Finally, from eq. (17), we find $d(\phi^*/(1-\phi^*))/d\beta$:

$$\frac{d(\phi^*/(1-\phi^*))}{d\beta} = \frac{C}{D}, \tag{21}$$

$$\textit{where} \ C \equiv \frac{1}{1+\zeta}\left[\left(\beta^{-\zeta}\gamma\right)^{1/(1+\zeta)} + \left(\beta\gamma^{-\zeta}\right)^{1/(1+\zeta)}\right], \ D \equiv \gamma^{2/(1+\zeta)}.$$

Clearly, $(d(\phi^*/(1-\phi^*))/d\beta) \succ 0$ if $\beta + \gamma \succ 0$.

We know that $\alpha + \beta + \gamma = 1$, and $0 \prec \alpha \prec 1$. From this it follows that $\beta + \gamma \succ 0$ $\Rightarrow (d(\phi^*/(1-\phi^*))/d\beta) \succ 0$.

[7] As we shall see later, empirically it turns out that the current—rather than capital—component of expenditure is the more productive. In the light of this, g_1 should be interpreted as current rather than capital expenditure. An increase in the share of current expenditure in the production function ought to favour, rather than hinder, growth, contrary to popular belief.

Table 1 Simulation results for (λ^*, τ^*, ϕ^*) corresponding to different values of α, β, γ

α	β	γ	λ^*	τ^*	ϕ^*
0.50	0.25	0.25	0.00520	0.6300	0.5000
0.50	0.30	0.20	0.00572	0.6282	0.5837
0.50	0.40	0.10	0.01089	0.6128	0.7605
0.50	0.45	0.05	0.01790	0.5964	0.8619
0.60	0.20	0.20	0.02609	0.5231	0.5000
0.60	0.25	0.15	0.02733	0.5208	0.6048
0.60	0.30	0.10	0.03151	0.5134	0.7141
0.60	0.35	0.05	0.04073	0.4993	0.8350
0.75	0.15	0.10	0.09047	0.3526	0.5837
0.75	0.20	0.05	0.10025	0.3439	0.7605

For the simulations, the other parameter values chosen are as follows: $\zeta = 0.2$, $\sigma = 2$, $\rho = 0.02$.

Having derived the comparative statics results analytically, we proceed to verify numerically, how the optimal values of (λ, τ, ϕ) change with changes in β.[8] The numerical simulation results are reported in Table 1. The choice of values for the parameters, ρ and σ, follows Barro (1990). $\zeta = 0.2$ makes the elasticity of substitution ($= 1/(1+\zeta)$) close to that for a standard Cobb-Douglas function.

As we are concerned with a (positively) growing economy, we restrict our parameter choices to conform to positive growth rates.[9] The simulations clearly show that increasing the share (β) of the more productive public good (g_1) raises the economy's optimal growth rate and reduces the optimal tax rate.

3. Empirical analysis

Like Devarajan *et al.* (1996), our empirical analysis focuses on the link between various components of government expenditure and economic growth in developing countries, but we try to establish this link in the context of optimal fiscal policy, where one of the public inputs has higher productivity in the sense that it has a larger share in the production function, *a priori*. As regards productive public goods, Aschauer (1989) finds that investment in core infrastructure in the US raised the productivity of private capital over a period of almost 40 years (1949–85), leading to higher growth; and Easterly and Rebelo (1993) find that public investment in transport and communications has a direct impact on growth. On the contrary, Evans and Karras (1994) and Holtz-Eakin (1994) both showed, after controlling for unique state effects, that the elasticity of output with respect to public capital was not significantly different from zero in a panel

[8] As $\beta = 1-\alpha-\gamma$, higher β (for given α) automatically implies lower γ.

[9] Devarajan *et al.* (1996) too assume a positive growth rate ($\lambda > 0$) in their model.

of 48 US states. Although the economic classification of expenditure is considered for much of the empirical analysis of this paper, we also consider the functional classification[10] in Section 4, where we study the impact of expenditure on health and education (both being components of capital expenditure), and O&M (which is part of current expenditure) on the growth rate.

As far as investigation into the effect of different constituents of public expenditure on growth is concerned, we have noted in the introduction that Devarajan *et al.* (1996) found a positive (negative) and significant relationship between the current (capital) component of public expenditure and *per capita* real GDP growth for 43 countries from 1970 through 1990. In an empirical study with a sample of 39 low income countries (all with IMF-supported programmes) during the period, 1990–2000, Gupta *et al.* (2005) show that fiscal consolidations achieved through cutting selected current expenditures tend to raise growth rates, while protecting capital expenditures does the same. Though this result is consistent with developed country experiences, it contradicts the results of Devarajan *et al.* (1996) and ours, as will be clear from Section 3.3.

Like Devarajan *et al.* (1996), we do not classify public expenditures as being productive and unproductive to begin with, but let the data 'do the talking'. As we shall see, if the regression results show that capital expenditures, which are thought to be more productive than current expenditure *a priori*, do show themselves to be having more growth effects, then we can say that capital items are indeed more productive than current items. If, on the other hand, optimal fiscal policies dictate that growth rates ought to be higher when the share of *a priori* more productive (i.e., capital) expenditure exceeds that of *a priori* less productive (i.e., current) expenditure, but the regressions show that this is not the case, then we can conclude that current rather than capital spending has been the more productive component, contrary to popular belief.

Like Devarajan *et al.* (1996), we consider a sample consisting of only developing countries, whereas most existing studies consider either a mixed sample of developed and developing countries or focus exclusively on developed countries. As in their study, we have a pooled cross-section/time series data set, which enables us to capture some of the lags involved in translating productive public expenditures into economic growth.

3.1 Data and choice of variables

The empirical analysis uses panel data on 15 countries,[11] from 1972 to 1999, to examine the link between components of government expenditure and growth

[10] For a detailed description of the classification of expenditure, see Devarajan *et al.* (1996, p.323, footnote 9).

[11] The countries chosen for our study are as follows: Argentina, Brazil, Chile, Colombia, Mexico (South America), Cameroon, Kenya, Sudan, Tanzania, Zimbabwe (Africa), India, Indonesia, Malaysia, Pakistan, Thailand (Asia).

from a welfare-maximizing perspective.[12] We use annual data obtainable from the Global Development Network Growth Database compiled by William Easterly.[13]

The model in Section 2 linked growth with productivities from an OFP perspective: clearly, from eq. (18), the optimal growth rate, λ^* is linked to the parameters, α, β, γ, σ, and ρ, and as eq. (19), Section 3 shows, $d\lambda^*/d\beta > 0$ depends on $\beta > \gamma$. In other words, the share in the production function of the 'objectively' more productive input has to be greater than that of the less productive input. It now remains to be seen whether it is the capital component of expenditure in the production function that is the more productive input and the current component of expenditure that is the less productive input, or the other way round.

To control for level effects, we include the share of government spending in GDP. As is clear from the theoretical model, the optimal income tax rate (which turns out to be the share of government spending in GDP, given that government spending is wholly productive, and income taxes are the only form of taxes) is a function of the parameters α and β, with $d\tau^*/d\beta < 0$ depending on $\beta > \gamma$. This also allows us to control for the effects of financing government expenditure on growth.[14]

The other important determinant of the growth rate that we consider for our empirical analysis is the ratio of private to public capital. This follows directly from our theoretical model of Section 2 (see eqs (6), (10), and (11) for expressions for g/k, g_1/k, and g_2/k respectively).[15] Consequently, the capital-output ratio as a proportion of the public spending-output ratio is treated as a regressor in the growth equation.[16]

The dependent variable is chosen as the per capita real GDP growth rate in the first set of regressions (Table 2). As pointed out by Devarajan *et al.* (1996), in order to account for the possible reverse causality between spending on public goods and the effect on output growth, we use a five-year forward moving average of growth to eliminate business cycle-type short-run fluctuations induced by shifts in public spending, and this also increases the number of time series observations in our

[12] On the panel data approach to studying empirical growth models, see Islam (1995).

[13] We have chosen 15 major countries from the three continents for which the complete data set was available from the Easterly database.

[14] In Section 5, we take account of the revenue side of the government budget constraint more fully by considering tax and non-tax revenues, and also the government budget deficit/surplus.

[15] As pointed out by an anonymous referee, an issue of some concern could be that measurement error in the capital stock may dominate its empirical variation. An alternative, therefore, would be to include a measure of current investment, as public spending in models like ours promotes growth by enabling private investment. We have consequently re-run the regressions, replacing gross fixed capital formation by private investment. The results (not reported) turn out to be very similar to those with private capital, and are available upon request. It is also worth mention that our results on the magnitude of the impact of private investment on the rate of growth are quite similar to those obtained by Gupta *et al.* (2005) and Bose *et al.* (2007).

[16] Note that the Easterly database provides data on gross fixed capital formation as a percentage of GDP, and the same is true of public capital and current spending (g_{cap} and g_{cur} respectively), which are also expressed as percentages of GDP.

panel data. The empirical results with the five-year moving average are provided in Table 3.

As in Devarajan *et al.* (1996), we include the 'black market premium' variable to capture the effects of other domestic policies (i.e., other than productive public spending) in countries that also affect the growth rate, given that there is generally a black market for foreign exchange in developing countries. This variable, obtained from the Easterly database, is the premium on the official rate in the black market for foreign exchange. Here bmp_{it} in country i at time t is calculated as $bmp_{it} = [(bmer_{it} - oer_{it})/oer_{it}]^{*}100$, where $bmer \equiv$ black market exchange rate, and $oer \equiv$ official exchange rate.

Finally, we include two explanatory independent variables to capture the 'international' dimension. Given that ours is a sample of developing countries, a measure to control for external shocks could be quite important (see Easterly *et al.*, 1993). The 'shock' term that we use is a weighted average of changes in the world interest rate, the export price index and the import price index for each country, to capture the effects of external shocks to these economies, as in Devarajan *et al.* (1996). Also, *à la* Rodrik (1998), who argues that openness to international trade is an important variable in empirical models testing fiscal policy and growth, we include 'openness' which is the sum of exports and imports as a ratio of GDP as a regressor.

The model specification for the first set of regressions is:

$$G_{it} = a_i + b_t + f_1\left(\frac{g_{cap,\,it}}{g_{cap,\,it} + g_{cur,\,it}}\right) + h\left(\frac{g_{cap,\,it} + g_{cur,\,it}}{y_{it}}\right) + j\left(\frac{k_{it}}{g_{cap,\,it} + g_{cur,\,it}}\right) + l(bmp_{it}) + m(shock_{it}) + n(openness_{it}) + e_{it} \quad (22)$$

where i and t denote the cross-sectional and time series dimensions respectively; a_i captures the time-invariant unobserved country-specific fixed effects, and b_t captures the unobservable individual-invariant time effects. G is the *per capita* real GDP growth rate, g_{cap} is public 'capital expenditure', g_{cur} is public 'current expenditure', y is GDP, k is the gross fixed capital formation, *bmp* is the black market premium, and the 'shock' and 'openness' variables are as defined in the previous paragraph.

The model specification for the second set of regressions is:

$$G_{it} = a_i + b_t + f_2\left(\frac{g_{cur,\,it}}{g_{cap,\,it} + g_{cur,\,it}}\right) + h\left(\frac{g_{cap,\,it} + g_{cur,\,it}}{y_{it}}\right) + j\left(\frac{k_{it}}{g_{cap,\,it} + g_{cur,\,it}}\right) + l(bmp_{it}) + m(shock_{it}) + n(openness_{it}) + e_{it} \quad (23)$$

which differs from eq. (22) in that the first term in brackets on the right-hand side of the equality in (23) is current expenditure as a proportion of total government expenditure.[17]

[17] Gupta *et al.* (2005) have run their regressions with public capital expenditure and the various components of current expenditure in the same regression equation, rather than in separate equations

3.2 Methodology

The effects of fiscal policy when the tax rate and government expenditure shares are exogenously given, can be adequately captured by the OLS fixed effects model. But the GMM single equation model, it can be argued, captures the endogeneity aspects of the model better, given the cross-country heterogeneity in the data. This is why we use the latter method for our estimations. As for the OFP exercise, we feel that the GMM system is probably the ideal methodology to capture the endogeneity involved in the simultaneous determination of the key variables (ϕ^*, λ^*, τ^*) in the theoretical model.[18] In a model where the shares of the more and less productive inputs are arbitrarily fixed, fiscal policy can be captured by the OLS fixed effects model and/or the GMM single equation model. But in the OFP version, clearly optimal ϕ (ϕ^*) is not an arbitrarily chosen constant, but is determined endogenously in terms of the parameters, α and β. The same applies for optimal λ and τ. This joint determination of variables in the OFP case distinguishes our study from that of Devarajan *et al.* (1996) on the theoretical side, while our use of the GMM system to capture OFP distinguishes our work from the authors on the empirical side.[19]

The OLS fixed effects model, also known as the Least Squares Dummy Variable (LSDV) model, and the Instrumental Variable estimator are often applied to panel estimations. Even though these methods are extensively used in the panel literature, they fail to capture cross-country heterogeneity. In order to capture the cross-country heterogeneity in the data, we use the system GMM estimator. The GMM estimators developed by Arellano and Bond (1991) make use of lagged instruments of the endogenous variables for each time period to tackle possible endogeneity of the explanatory variables in the panel.[20] For a brief description of the GMM panel estimators we rewrite our equation as:

$$G_{it} = a_i + b_t + X_{it} + e_{it}$$

where G_{it} is the GDP growth for country i at time period t, a_i is the time-invariant unobserved country-specific fixed effect (e.g., differences in the initial level of GDP growth), b_t captures the unobservable individual-invariant time effects (e.g., shocks that are common to all countries), X_{it} is a vector of the explanatory variables and

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like us. For purposes of comparison, we too have done the same. Our results are robust to this alternative specification. These results are not reported here, but are obtainable upon request.

[18] From the theoretical model in Section 2, it is clear that while in eq. (7), λ is expressed in terms of τ (exogenous) and ϕ (exogenous); in eq. (18), λ^* (optimal λ) is expressed in terms of τ^* (optimal τ - endogenous), and ϕ^* (optimal ϕ - endogenous).

[19] Gupta *et al.* (2005) attempt to address the endogeneity problem by using the GMM (single equation) estimator, as we do, but do not use the system GMM, which we use in order to capture OFP.

[20] To this end, we perform the Hausman test. The Hausman test is a test for the hypothesis that the explanatory variables are strictly exogenous. If the null hypothesis that the explanatory variables are strictly exogenous is rejected, it leads to the conclusion that the explanatory variables in the fixed effects model are endogenously determined. In order to resolve the issue of endogeneity, we use lags of the explanatory variables as instruments in the GMM methodology.

e_{it} is the error for country i at time period t. If $E\ (e_{it}\ e_{iz}) = 0$ holds for $z \neq t$ across all the countries then it represents the following moment conditions:

$$E\big(G_{i,\,t-z}\Delta e_{it}\big) = 0 \text{ for } z \geqslant 3; \quad t = 3, \ldots\ldots., T.$$

If X_{it} are weakly exogenous then we also have the following additional moment conditions:

$$E\big(X_{i,\,t-z}\Delta e_{it}\big) = 0 \text{ for } z \geqslant 3; \quad t = 3, \ldots\ldots., T.$$

The single equation GMM panel estimator generally specifies a dynamic panel model in first differences and exploits the above moment conditions.[21] Therefore, the lagged (three time periods or more) levels of endogenous and weakly endogenous variables of the model become appropriate instruments for addressing endogeneity. The single GMM panel estimator provides consistent coefficient estimates.

However, when the time-series dimension of the panel is fairly small, the single equation estimator suffers from the problem of weak instruments. In other words, there is a weak correlation between the regressors and the instruments. As a result of this problem, the estimated coefficients suffer from poor precision (see, among others, Staiger and Stock, 1997). We can overcome this problem by using the panel GMM system estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998), which radically reduces the imprecision associated with the single equation estimator. The system GMM estimator estimates a system of equations in first differences and levels by stacking the data. It combines the standard set of (T-z) transformed equations with an additional set of (T-z) equations in levels (note $z \geqslant 3$). The first set of transformed equations continues to use the lag levels as instruments. The level equation, on the other hand, uses the lagged first differences as instruments. Their validity is based on the following moment conditions:[22]

$$E\big[(a_{it} + e_{it})\ \ \Delta G_{i,\,t-z}\big] = 0 \quad for \quad z = 1$$
$$E\big[(a_{it} + e_{it})\ \ \Delta X_{i,\,t-z}\big] = 0 \quad for \quad z = 1$$

Bond *et al.* (2001) show that the system GMM estimator performs better then a range of other method of moment type estimators. In order to provide a comparison between the estimates obtained from the GMM single equation and the GMM system estimators, we perform a Hausman test. Namely, we perform a Hausman test comparing the GMM single equation estimates to those obtained by adding lagged first differences to the set of instruments (additional instrument used in the GMM system estimates). If the test rejects the null hypothesis that the two estimates are not significantly different, then the GMM system estimator is significantly different to the GMM single equation estimator.

[21] The model is transformed into first differences in order to eliminate the fixed effects.

[22] The time-varying matrix of instruments for the first difference GMM estimator can be observed in Blundell and Bond (1998).

The consistency of GMM estimators hinges crucially on whether the lagged values of the explanatory variables are a valid set of instruments and whether e_{it} is not serially correlated. We undertake Sargan's instrument validity test (applicable to single equation GMM) and the Difference-Sargan test (applicable to system GMM) to establish the validity of the instrument set. A first order serial correlation test is performed to test whether the error term suffers from serial correlation.

3.3 Empirical estimates and explanation of results

In all the empirical estimates, the fixed and time effects of the panel both appear significant, implying that the country- and time-specific shocks differ significantly across the nations in our sample. All empirical tables report Hausman tests for the hypothesis that the explanatory variables are strictly exogenous. In our empirical estimates, this test strongly rejects the null hypothesis. This leads to the conclusion that the explanatory variables in the fixed effects model are endogenously determined (apart from the *bmp*, shock and openness variables, which are exogenous).

In addition, all estimated models pass the diagnostic tests.[23] A test for first order residual serial correlation is insignificant which suggests that the panels do not suffer from serial correlation.[24] Sargan tests confirm the validity of the instruments in both GMM models.

Table 2 shows that there is a negative and statistically significant relationship between the capital component of public expenditure and optimal growth, and this is surprising at first glance, although a similar negative relation is obtained by Devarajan *et al.* (1996). Note, however, that here we are studying the link between optimal growth and public investment.[25] From the OLS fixed effects model, we find that a unit increase in the ratio of public capital to total public spending decreases per capita real GDP growth by 23 percentage points. A similar negative coefficient is obtained for the GMM single equation model, and for the GMM system, once again a negative coefficient is obtained.

In the same regression, the public expenditure-to-GDP ratio is positive and statistically significant using all three methodologies. This is the level effect of total government spending on per capita growth, which has been found to be positive but insignificant by Devarajan *et al.* (1996). So this result of ours is somewhat different from their findings. This is intuitive, since we would generally expect that under OFP, the desirable condition that the productivity of public spending

[23] We used three lags in our estimations, but also experimented with other lag structures. Our results are robust to one, two, and four lags. These results are obtainable upon request.

[24] It should be noted that the serial correlation test for the GMM is done on the first difference of the residuals, whereas for the OLS (fixed effect) it is done on the actual residuals.

[25] Note that the GMM system is used to capture OFP for the model (the aspect of joint determination of optimal values for the growth rate, tax rate and expenditure shares). We report only the growth rate estimates here in the fourth column of the Tables (under the 'GMM System' heading), as—from an empirical standpoint—we are primarily interested in the growth effects of the different components of government spending.

Table 2 Contribution of the capital component of public spending (among others) to optimal growth

$$G_{it} = a_i + b_t + f_1\big((g_{cap,\,it})/(g_{cap,\,it} + g_{cur,\,it})\big) + h\big((g_{cap,\,it} + g_{cur,\,it})/(y_{it})\big) + j\big((k_{it})/(g_{cap,\,it} + g_{cur,\,it})\big) + l(bmp_{it}) + m(shock_{it}) + n(openness_{it}) + e_{it}$$

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	13.53 *(2.03)**	13.46 *(2.33)**	13.41 *(2.40)**
$g_{cap}/(g_{cap}+g_{cur})$	−0.23 *(−2.52)**	−0.16 *(−2.15)**	−0.17 *(−2.19)**
$(g_{cap}+g_{cur})/y$	0.35 *(3.03)**	0.37 *(2.94)**	0.40 *(2.79)**
$k/(g_{cap}+g_{cur})$	0.48 *(2.18)**	0.52 *(2.26)**	0.54 *(2.27)**
bmp	−0.005 *(−0.74)*	0.006 *(1.11)*	0.007 *(1.06)*
Shock	0.115 *(0.78)*	0.118 *(0.84)*	0.120 *(0.90)*
Openness	0.213 *(1.04)*	0.221 *(1.09)*	0.225 *(1.11)*
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.126	0.125	0.123
AR(1)	(0.378)	(0.391)	(0.437)
Sargan χ^2 (r)	NA	248.9[473]	271.2[490]
Diff Sargan χ^2 (r)	NA	NA	38.9[48]
Hausman test	78.73		
Observations	267	267	267

For the OLS (fixed effects) model, AR(1) is the first order Lagrange Multiplier test for residual serial correlation. SE represents the standard error of the panel estimator. Under GMM single equation and GMM system, this test is undertaken on the first difference of the residuals because of the transformations involved. a_i and b_t are the fixed and time effects. Sargan tests follow a χ^2 distribution with r degrees of freedom under the null hypothesis of valid instruments. The Hausman test follows a χ^2 distribution with six degrees of freedom, resulting in a critical value of 14.45, at the 95% confidence level. The endogenous explanatory variables in the panel are GMM instrumented setting $z \geqslant 3$.
(.) are p values, *(.)* are t statistics, *indicate significant at all conventional levels.

(that is financed by income taxes) exceeds the deadweight loss associated with distortionary taxation would be satisfied.

Our theoretical model of Section 2 solves for an optimal value of k/g (ratio of private capital to public services), which is one of the important endogenous variables of our model. Hence, unlike Devarajan *et al.* (1996), we include this as an important determinant of the optimal growth rate. The coefficient on this variable is positive and significant for OLS (fixed effects), GMM (single equation) and the GMM system (and its value ranges from 0.45 to 0.55 in the three methods). The positive sign is clearly intuitive, given that public services in this model augment the productivity of private capital, and we would expect it to be significant.

The black market premium is statistically insignificant in all the regressions. This shows that factors other than the shares of public spending, the public spending-to-output ratio and the private-to-public spending ratio are insignificant in determining the welfare-maximizing growth rate. Note that in Devarajan *et al.* (1996), this variable is statistically significant in most of the regressions. The reason for this could be that this variable picks up some of the effects of the private-to-public spending ratio in their regressions, whereas in our case the latter variable is clearly an important determinant of the growth rate.

Table 3 Contribution of the capital component of public spending (among others) to optimal growth (with five-year forward moving average of growth)

$$G_{it} = a_i + b_t + f_1\big((g_{cap,it})/(g_{cap,it} + g_{cur,it})\big) + h\big((g_{cap,it} + g_{cur,it})/(y_{it})\big) + j\big((k_{it})/(g_{cap,it} + g_{cur,it})\big) + l(bmp_{it}) + m(shock_{it}) + n(openness_{it}) + e_{it}$$

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	13.63 *(2.15)**	13.44 *(2.34)**	13.40 *(2.36)**
$g_{cap}/(g_{cap}+g_{cur})$	−0.20 *(−2.55)**	−0.14 *(−2.17)**	−0.15 *(−2.24)**
$(g_{cap}+g_{cur})/y$	0.34 *(3.06)**	0.35 *(2.92)**	0.41 *(2.76)**
$k/(g_{cap}+g_{cur})$	0.46 *(2.19)**	0.53 *(2.28)**	0.55 *(2.30)**
bmp	−0.006 *(−0.77)*	0.008 *(1.15)*	0.008 *(1.11)*
Shock	0.117 *(0.80)*	0.119 *(0.85)*	0.122 *(0.93)*
Openness	0.216 *(1.07)*	0.224 *(1.12)*	0.226 *(1.17)*
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.127	0.125	0.124
AR(1)	(0.379)	(0.393)	(0.442)
Sargan χ^2 (r)	NA	248.8[473]	271.1[490]
Diff Sargan χ^2 (r)	NA	NA	38.8[48]
Hausman test	78.79		
Observations	267	267	267

See notes for Table 2.

Table 4 Contribution of the current component of public spending (among others) to optimal growth

$$G_{it} = a_i + b_t + f_2\big((g_{cur,it})/(g_{cap,it} + g_{cur,it})\big) + h\big((g_{cap,it} + g_{cur,it})/(y_{it})\big) + j\big((k_{it})/(g_{cap,it} + g_{cur,it})\big) + l(bmp_{it}) + m(shock_{it}) + n(openness_{it}) + e_{it}$$

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	13.22 *(2.22)**	13.20 *(2.43)**	13.14 *(2.47)**
$g_{cur}/(g_{cap}+g_{cur})$	0.20 *(2.69)**	0.17 *(2.25)**	0.16 *(2.40)**
$(g_{cap}+g_{cur})/y$	0.31 *(3.09)**	0.35 *(2.97)**	0.32 *(2.80)**
$k/(g_{cap}+g_{cur})$	0.45 *(2.23)**	0.48 *(2.24)**	0.46 *(2.36)**
bmp	−0.005 *(−0.79)*	0.005 *(1.19)*	0.008 *(1.10)*
Shock	0.122 *(1.01)*	0.134 *(1.09)*	0.138 *(1.11)*
Openness	0.219 *(1.12)*	0.225 *(1.18)*	0.235 *(1.20)*
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.129	0.125	0.124
AR(1)	(0.389)	(0.424)	(0.429)
Sargan χ^2 (r)	NA	250.2[475]	270.7[487]
Diff Sargan χ^2 (r)	NA	NA	38.9[49]
Hausman test	75.62		
Observations	267	267	267

See notes for Table 2.

Table 5 Contribution of the current component of public spending (among others) to optimal growth (with five-year forward moving average of growth)

$$G_{it} = a_i + b_t + f_2((g_{cur,it})/(g_{cap,it} + g_{cur,it})) + h((g_{cap,it} + g_{cur,it})/(y_{it})) + j((k_{it})/(g_{cap,it} + g_{cur,it})) + l(bmp_{it}) + m(shock_{it}) + n(openness_{it}) + e_{it}$$

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	13.26 *(2.29)**	13.24 *(2.45)**	13.16 *(2.49)**
$g_{cur}/(g_{cap}+g_{cur})$	0.19 *(2.72)**	0.16 *(2.23)**	0.15 *(2.41)**
$(g_{cap}+g_{cur})/y$	0.32 *(3.06)**	0.37 *(2.94)**	0.33 *(2.83)**
$k/(g_{cap}+g_{cur})$	0.43 *(2.22)**	0.49 *(2.21)**	0.45 *(2.30)**
bmp	−0.005 *(−0.81)*	0.007 *(1.27)*	0.009 *(1.17)*
Shock	0.125 *(1.03)*	0.137 *(1.02)*	0.139 *(1.17)*
Openness	0.219 *(1.12)*	0.225 *(1.18)*	0.235 *(1.20)*
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.130	0.126	0.125
AR(1)	(0.392)	(0.426)	(0.433)
Sargan χ^2 (r)	NA	250.1[475]	270.7[487]
Diff Sargan χ^2 (r)	NA	NA	38.8[49]
Hausman test	73.23		
Observations	267	267	267

See notes for Table 2.

As is clear from the results, the shock variable is insignificant. A possible reason why the shock is not important could be that the time dummy is picking up the influence of the shock. This is because it is likely that any shock will be time varying.

The only difference between the first and second set of regressions—for which the results are provided in Table 3—is that in Table 3, the five year forward moving average of the growth rate is used, rather than the growth rate itself. The results are remarkably similar to those in Table 2, which suggests that our results are robust to the reverse causality problem.

Table 4 presents the results for the regression of growth against the ratio of current public spending to total public spending, with other variables remaining as they were in Table 2. The coefficient on $g_{cur}/(g_{cap}+g_{cur})$ is now positive and significant, which contradicts accepted notions of how current spending ought to affect the growth rate, but is in accordance with the results obtained by Devarajan *et al.* (1996) for the same variable (their eq. (3.1), p.332). In the OLS fixed effects model specification, a unit increase in the $g_{cur}/(g_{cap}+g_{cur})$ ratio increases per capita real GDP growth by 20 percentage points. The coefficients on the other important variables remain strikingly similar to what was obtained in Table 2, and this is true for OLS (fixed effects), GMM (single equation) as well as the GMM system.[26]

[26] We implement a Hausman test to compare the GMM single equation estimates with those obtained from the GMM system estimator, which adds lagged first differences as additional instruments of the explanatory variables. The results of the test are equal to 0.435 for the GMM system of growth on g_{cap}, while it is 0.441 for the GMM system of growth on g_{cur}. This is smaller than the critical value

Finally, Table 5 presents the same model as Table 4, but with the five-year forward moving average of growth. The striking similarity with Table 4 shows that the results are robust to reverse causality and to alternative specifications.

An interesting feature of our empirical exercise is that the coefficient estimates for public capital and current expenditure appear significantly greater than in the study by Devarajan *et al.* (1996). A possible factor behind this is that the standard deviation of g_{cap} is 38.2, and the standard deviation of g_{cur} is 35.4. These turn out to be much larger than in Devarajan *et al.* (1996), who report standard deviations of 12.62 and 12.64 (p.335) for public capital and current expenditure, respectively. A possible reason for the significantly larger volatility could be the smaller sample size: 15 countries as against 43 in Devarajan *et al.* (1996). The small number of observations in our sample may result in large jumps in the public capital and current expenditure variables, which could explain the larger coefficients that we obtain.

One potential problem with the use of the GMM system estimator is that the properties hold when the number of countries is large. Therefore, the GMM system estimator may be biased and imprecise in our sample, given that we only have 15 countries. An alternative approach to the GMM system estimator is based on the bias- correction of the LSDV model. Nickell (1981) demonstrates that the standard LSDV estimator is not consistent when the number of countries in the panel is small. Kiviet (1995) uses higher order asymptotic expansion techniques to approximate the small sample bias of the LSDV estimator.[27] These approximations are evaluated at the unobserved true parameter values, so they cannot be estimated. Kiviet (1995) overcomes this shortcoming by replacing the true unobserved parameters with the estimates from some consistent estimators.

Therefore, for robustness we re-estimate the OLS fixed effects model in Tables 2 and 4 using the small sample bias correction provided by Kiviet (1995). The results can be seen in Tables 2a and 4a in Appendix 2. As we can see, the OLS fixed effects results do not change, providing evidence that the panel GMM system estimator computes reliable parameter estimates for our sample, even though we only have 15 countries.[28]

4. Robustness

4.1 Robustness tests for sub-samples of high-income and low-income countries

In this section, we check whether our results of the previous section regarding the contributions of capital and current spending are robust to the choice of different

(14.45, at the 95% confidence level), which means that we accept the null hypothesis that the GMM single equation and GMM system estimates are not significantly different.

[27] We thank Jonathan Temple for suggesting us to use Kiviet's bias-adjusted LSDV estimator.

[28] For completeness we also estimated Tables 3 and 5 with the use of the OLS fixed effects small sample bias correction. The OLS fixed effects results do not change. The results are not reported and are available upon request from the authors.

country samples. We believe this is an important robustness test, given that in Gupta *et al.* (2005) the empirical estimates were based on low-income countries alone. In an ideal scenario, we would like to have included more low-income countries to our sample, but unfortunately, the Easterly database only enables

Table 6a Contribution of the capital component of public spending (among others) to optimal growth for high income countries

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	15.62 *(2.13)**	15.50 *(2.69)**	15.45 *(2.56)**
$g_{cap}/(g_{cap}+g_{cur})$	−0.13 *(−2.66)**	−0.09 *(−2.27)**	−0.08 *(−2.23)**
$(g_{cap}+g_{cur})/y$	0.20 *(3.17)**	0.19 *(2.89)**	0.18 *(2.83)**
$k/(g_{cap}+g_{cur})$	0.31 *(2.30)**	0.34 *(2.26)**	0.31 *(2.26)**
bmp	−0.003 *(−0.87)*	0.006 *(1.29)*	0.007 *(1.16)*
Shock	0.116 *(0.72)*	0.112 *(0.80)*	0.116 *(0.95)*
Openness	0.219 *(1.07)*	0.225 *(1.12)*	0.229 *(1.17)*
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.126	0.125	0.124
AR(1)	(0.375)	(0.417)	(0.424)
Sargan χ^2 (*r*)	NA	253.7[478]	273.4[494]
Diff Sargan χ^2 (*r*)	NA	NA	38.1[44]
Hausman test	77.89		
Observations	107	107	107

See notes for Table 2.

Table 6b Contribution of the capital component of public spending (among others) to optimal growth for low income countries

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	11.29 *(2.27)**	10.52 *(2.60)**	10.41 *(2.61)**
$g_{cap}/(g_{cap}+g_{cur})$	−0.07 *(−2.11)**	−0.06 *(−2.22)**	−0.06 *(−2.33)**
$(g_{cap}+g_{cur})/y$	0.19 *(3.24)**	0.16 *(2.96)**	0.13 *(2.76)**
$k/(g_{cap}+g_{cur})$	0.28 *(2.31)**	0.36 *(2.40)**	0.30 *(2.29)**
bmp	−0.006 *(−0.99)*	0.007 *(1.26)*	0.005 *(1.20)*
Shock	0.123 *(0.88)*	0.117 *(0.92)*	0.119 *(1.04)*
Openness	0.220 *(1.14)*	0.225 *(1.17)*	0.234 *(1.24)*
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.129	0.125	0.121
AR(1)	(0.396)	(0.452)	(0.467)
Sargan χ^2 (*r*)	NA	250.1[482]	273.2[493]
Diff Sargan χ^2 (*r*)	NA	NA	39.6[47]
Hausman test	70.36		
Observations	160	160	160

See notes for Table 2.

Table 7a Contribution of the current component of public spending (among others) to optimal growth for high income countries

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	12.64 *(2.37)**	12.20 *(2.70)**	12.14 *(2.43)**
$g_{cur}/(g_{cap}+g_{cur})$	0.12 *(2.74)**	0.10 *(2.26)**	0.08 *(2.32)**
$(g_{cap}+g_{cur})/y$	0.26 *(3.32)**	0.17 *(2.60)**	0.16 *(2.73)**
$k/(g_{cap}+g_{cur})$	0.32 *(2.27)**	0.28 *(2.25)**	0.27 *(2.26)**
bmp	−0.005 *(−0.90)*	0.007 *(1.30)*	0.008 *(1.20)*
Shock	0.116 *(0.79)*	0.112 *(0.87)*	0.119 *(0.90)*
Openness	0.224 *(1.11)*	0.228 *(1.26)*	0.231 *(1.16)*
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.129	0.127	0.126
AR(1)	(0.317)	(0.390)	(0.396)
Sargan χ^2 (r)	NA	254.7[484]	273.8[496]
Diff Sargan χ^2 (r)	NA	NA	38.1[44]
Hausman test	76.37		
Observations	107	107	107

See notes for Table 2.

Table 7b Contribution of the current component of public spending (among others) to optimal growth for low income countries

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	11.23 *(2.43)**	10.43 *(2.69)**	10.21 *(2.72)**
$g_{cur}/(g_{cap}+g_{cur})$	0.14 *(2.19)**	0.12 *(2.23)**	0.09 *(2.16)**
$(g_{cap}+g_{cur})/y$	0.26 *(3.20)**	0.18 *(2.80)**	0.16 *(2.76)**
$k/(g_{cap}+g_{cur})$	0.30 *(2.30)**	0.36 *(2.35)**	0.33 *(2.29)**
bmp	−0.005 *(−0.85)*	0.008 *(1.33)*	0.009 *(1.18)*
Shock	0.119 *(0.74)*	0.115 *(0.89)*	0.119 *(0.96)*
Openness	0.224 *(1.09)*	0.228 *(1.14)*	0.232 *(1.20)*
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.127	0.124	0.122
AR(1)	(0.392)	(0.453)	(0.468)
Sargan χ^2 (r)	NA	250.2[482]	270.0[487]
Diff Sargan χ^2 (r)	NA	NA	38.0[44]
Hausman test	69.76		
Observations	160	160	160

See notes for Table 2.

us to obtain a balanced panel for 15 countries, which represent our dataset. Therefore, in order to assess the robustness of our empirical estimates to high-income and low-income countries, we re-estimated Tables 2 and 4 for high- and low-income countries within our sample. We distinguish between high- and low-income countries with respect to the size of GDP. The results are very similar to our original results, as can be seen from Tables 6a–7b.[29]

4.2 Robustness tests by inclusion of some functional components of capital and current expenditure

In this section, we check for the robustness of our empirical results with respect to some important (functional) components of government capital expenditure (like education and health) and also some important components of current expenditure (like operations and maintenance), because it is possible that though overall public capital expenditure may show a negative relationship with growth, some functional components within overall capital spending may actually have done well in terms of contributing to growth. This means that although overall capital spending may turn out to be unproductive, there could be a case for increasing expenditure on some of its components, and vice versa for current spending. Consequently, we replace the explanatory variable, $g_{cap}/(g_{cap}+g_{cur})$ by two separate explanatory variables, health/$(g_{cap}+g_{cur})$ and education/$(g_{cap}+g_{cur})$ in the first regression, as health and education constitute two important functional components of public capital expenditure, in the sense that spending on health and education boosts human capital (see, for instance, Barro, 1991). Our regression results of Table 8 show that the coefficients on both these variables turn out to be negative and significant, which again seems counterintuitive from the point of view of *a priori* expectations, but is in line with the signs obtained for the capital component of public expenditure. Our results are generally in accord with Devarajan *et al.* (1996). As is evident from their Table 3, neither health expenditure *per capita* nor total public health expenditure as a share of total expenditure is positively related to the per capita growth rate, and the effect of the former on the growth rate is negative and significant. Precisely the same occurs with the respective ratios as regards educational expenditure, and per capita education spending is negative and significant.

We next look at one of the components of the government's current expenditure in terms of the functional classification: O&M expenditure. As data on O&M expenditure is not directly available, this is captured by the 'other purchases of goods and services' variable, which is a component of current expenditure within the Government Finance account in the Easterly database. The rationale behind this proxy is that the bulk of expenditures on other goods and services is comprised

[29] The empirical estimates reported are based on six high-income countries and nine low-income countries with respect to GDP. We have alternatively estimated a combination of eight high-income and seven low-income countries, and tried other combinations as well. The results do not change, and are available upon request. Although the sample in Gupta *et al.* (2005) is wider than ours while our time series is longer and includes their study period, and noting the fact that they consider the revenue side of the government budget constraint in full (see Section 5 of our paper), we can say that our results differ from theirs.

Table 8 Contribution of the health and education components of public capital spending (among others) to optimal growth

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	13.50 *(2.05)**	13.40 *(2.29)**	13.36 *(2.42)**
Health/$(g_{cap}+g_{cur})$	−0.13 *(−2.57)**	−0.07 *(−2.15)**	−0.06 *(−2.23)**
Edu/$(g_{cap}+g_{cur})$	−0.05 *(−2.22)**	−0.04 *(−2.21)**	−0.03 *(−2.16)**
$(g_{cap}+g_{cur})/y$	0.27 *(3.06)**	0.30 *(2.96)**	0.29 *(2.70)**
$k/(g_{cap}+g_{cur})$	0.40 *(2.12)**	0.41 *(2.25)**	0.43 *(2.30)**
bmp	−0.005 *(−0.80)*	0.004 *(1.20)*	0.003 *(1.00)*
Shock	0.118 *(0.80)*	0.119 *(0.87)*	0.125 *(0.94)*
Openness	0.201 *(1.07)*	0.204 *(1.11)*	0.200 *(1.19)*
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.124	0.123	0.120
AR(1)	(0.370)	(0.382)	(0.401)
Sargan χ^2 (r)	NA	248.8[473]	271.3[490]
Diff Sargan χ^2 (r)	NA	NA	38.8[48]
Hausman test	79.22		
Observations	267	267	267

See notes for Table 2.

Table 9 Contribution of the 'other goods and services' component of public current spending (among others) to optimal growth

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	13.27 *(2.29)**	13.30 *(2.47)**	13.10 *(2.50)**
Other $g\&s/(g_{cap}+g_{cur})$	0.17 *(2.72)**	0.14 *(2.30)**	0.13 *(2.47)**
$(g_{cap}+g_{cur})/y$	0.29 *(3.13)**	0.32 *(2.90)**	0.30 *(2.85)**
$k/(g_{cap}+g_{cur})$	0.40 *(2.20)**	0.42 *(2.27)**	0.44 *(2.37)**
bmp	−0.005 *(−0.82)*	0.006 *(1.22)*	0.005 *(1.14)*
Shock	0.125 *(1.04)*	0.132 *(1.11)*	0.139 *(1.16)*
Openness	0.201 *(1.14)*	0.211 *(1.20)*	0.217 *(1.15)*
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.130	0.127	0.125
AR(1)	(0.394)	(0.404)	(0.411)
Sargan χ^2 (r)	NA	250.5[476]	270.9[488]
Diff Sargan χ^2 (r)	NA	NA	39.1[50]
Hausman test	79.76		
Observations	267	267	267

See notes for Table 2.

by O&M expenditure, according to the Manual on Government Finance Statistics published by the IMF (1986).[30]

[30] See discussion in Tanzi and Davoodi (1997), who use the same proxy for O&M expenditure in their paper.

To check that our definition of O&M expenditure is robust to alternative proxies, we use a second proxy, 'current expenditure less (wages and salaries, employer contributions)'. This is in line with Tanzi and Davoodi (1997), who observe that governments often tend to award wage increases but cut O&M expenditures. So, increases in wages and salaries are interpreted as cuts in O&M expenditures in our case, as in theirs.[31]

Turning to the empirical results obtained using this variable, we can find from Table 9, that O&M expenditures have a positive and significant effect on the per capita growth rate. This is an important result, as it shows that although public capital expenditures *per se* may not be productive, the spending on their maintenance is, and this is one of the factors that makes the current component of public expenditure productive. It is worth noting that the Gupta *et al.* (2005) paper considers this variable as a determinant of the growth rate and finds that other goods and services (either as a proportion of GDP or of total public expenditure) are positive and significant in most of their regressions; so in their case, components of current spending other than O&M expenditures are responsible for the negative impact on growth.

5. The model with inclusion of alternative sources of government revenue

5.1 Extension to original theoretical model

In this section, we include a feature that is not present in the theoretical model of Devarajan *et al.* (1996)—which considers a balanced budget—and which is what we too assumed in our Section 2. Here we relax that assumption and incorporate the revenue side of the government budget constraint in full into the analysis. We provide below an outline of how the key equations of the basic analytical model will change with the introduction of this new feature.

In the presence of public borrowing, the government budget constraint will have to be modified to take into account the fact that the government's expenditure includes not only its spending on the two public goods, g_1, and g_2, but also its interest payments on debt. The revenue side is made up not only of tax revenues but also borrowing from the public. Consequently, the budget constraint of the government on rearranging is

$$g_1 + g_2 = \tau(y + rb) + \dot{b} - rb \qquad (2')$$

Defining the right-hand-side of (2′) as net revenue (NR), i.e., total revenue less interest payments on debt, the shares of NR that are used to finance government expenditures on the two public goods are respectively,

$$g_1 = \Phi(NR) \quad and \quad g_2 = (1 - \Phi)(NR). \qquad (3')$$

[31] The results based on this proxy for O&M expenditures concur with those obtained with the 'other purchases of goods and services' variable. These results (not reported) are available upon request.

The representative agent's budget constraint will now be

$$\dot{k} + \dot{b} = (1 - \tau)(y + rb) - c. \tag{5'}$$

The agent's optimisation problem is to choose c, $\dot{k}$ and $\dot{b}$ to maximize U in (4), taking the fiscal variables, together with k_0 and b_0 as given. The expression for the growth rate is given by (8), where using (1), we obtain

$$\frac{\partial y}{\partial k} = \alpha\left(\frac{y}{k}\right)^{1+\zeta} = r. \tag{24}$$

As before, the government's optimisation exercise yields (12) and (13) via the first order conditions.

From (24), using (1), (12) and (13), $r^{\star}$ can be expressed as

$$r^{\star} = \alpha^{-1/\zeta}\left(1 - \beta^{1/(1+\zeta)} - \gamma^{1/(1+\zeta)}\right)^{\frac{1+\zeta}{\zeta}}, \tag{25}$$

where $r^{\star}$ is the value taken by r when the government pursues OFP by choosing τ, g_1, and g_2.

As the model has no transitional (growth) dynamics, we focus on the balanced growth path where the debt-output ratio is constant, say, $b/y = \eta$. Noting this, the government budget constraint given by (2′) can be expressed, along the balanced growth path, as

$$(g_1 + g_2)/y + [(1 - \tau)r - \lambda]\eta - \tau = 0 \tag{26}$$

Combining (26) with (8), (12), and (13) enables us to solve for optimal τ in terms of the parameters of the model:

$$\tau^{\star} = \frac{(\sigma - 1)\eta r^{\star} + \eta\rho + \sigma\left[\beta^{1/(1+\zeta)} + \gamma^{1/(1+\zeta)}\right]}{\sigma + (\sigma - 1)\eta r^{\star}} \tag{14'}$$
$$\text{i.e.,}\quad \tau^{\star} = F^{1}(\alpha, \beta, \gamma, \zeta, \sigma, \rho, \eta).$$

From (8), using (14′), one can solve for optimal λ in terms of the parameters:

$$\lambda^{\star} = \frac{(1 - \tau^{\star})r^{\star} - \rho}{\sigma}, \tag{8'}$$
$$\text{i.e.,}\quad \lambda^{\star} = F^{2}(\alpha, \beta, \gamma, \zeta, \sigma, \rho, \eta).$$

Finally, from (3′), using (2′) and (12), we have

$$\Phi^{\star} = \frac{\beta^{1/(1+\zeta)}}{\tau^{\star}(1 + \eta r^{\star}) + \eta(\lambda^{\star} - r^{\star})} \tag{15'}$$
$$\text{i.e.,}\quad \Phi^{\star} = F^{3}(\alpha, \beta, \gamma, \zeta, \sigma, \rho, \eta).$$

Clearly, expressions for optimal λ, τ, and Φ are given by (8′), (14′), and (15′), when the revenue side of the government budget constraint comprises public borrowing in addition to tax revenues.

5.2 Empirical analysis

In this section, we assess whether our empirical results change with the inclusion of this feature that is not present in the Devarajan *et al.* (1996) model. From an empirical standpoint, not incorporating the government budget constraint in full into the analysis could have resulted in their parameter estimates being prone to systematic omitted variable bias. The empirical part of their paper, as we know, focuses almost exclusively on the expenditure rather than the revenue side of the government budget constraint, and this, according to some researchers, e.g., Kneller *et al.* (1999) and Bose *et al.* (2007) would tend to make their coefficient estimates biased, as one should ideally take into account both the sources and the uses of funds simultaneously in evaluating fiscal policy effects on growth.

In order to take the government budget constraint into account more fully, we incorporate government deficits (i.e., public borrowing) alongside taxes in our theoretical model, and derive OFP in the new set-up. We also amend our empirical specification to take into account variables on the financing side more fully, e.g., the government budget deficit/surplus, tax revenues and non-tax revenues. This will enable us to compare our new results with our benchmark specification, where the ratio of public spending to GDP (a proxy for the tax rate) was the only variable on the revenue side.

An issue worth noting is that perfect collinearity among regressors can be avoided by excluding an element of the government budget constraint. Gupta *et al.* (2005) exclude the budget balance but include tax revenues, while Bose *et al.* (2007) include budget balance and tax revenue, but exclude non-tax revenue. We, in a sense, combine the approaches of the aforementioned papers in having tax revenues, non-tax revenues as well as budget surpluses/deficits, but yet the collinearity problem does not arise because on the expenditure side, we include capital and current expenditure in separate regressions.

Tables 10 and 11 report the results of the new set of regressions, where clearly the main sources of funds are included as separate regressors. Tax revenue (TR) and non-tax revenue (NTR), as proportions of GDP, both turn out to be positive and significant. The overall deficit/surplus of the government, however, turns out to have an insignificant effect on the growth rate. Recall that in Tables 2–5, which were based on our theoretical model of Section 2, the variable, $(g_{cap}+g_{cur})/y$ captured the revenue effects of taxation (which was the only financing variable) and it was positive and significant. In this extension of the basic model, TR/y remains significant, and so is NTR/y. Comparing our results with Bose *et al.* (2007), we find that for them, TR has a negative impact (when significant) on growth.[32] As regards TR, our results are in sharp contrast to Gupta *et al.* (2005), for whom tax revenues as a percentage of GDP are always insignificant, while with respect to non-tax revenue, our results are similar in that in their case, non-tax revenues are

[32] The results of Kneller *et al.* (1999) suggest that the distinction between distortionary and non-distortionary taxation is important; and while the former reduces growth, the latter does not.

Table 10 Contribution of the capital component of public spending (among others) to optimal growth in the presence of three revenue-side variables in the government budget constraint

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	16.23 *(2.09)**	16.43 *(2.39)**	16.23 *(2.54)**
$g_{cap}/(g_{cap}+g_{cur})$	−0.27 *(−2.60)**	−0.19 *(−2.28)**	−0.20 *(−2.26)**
$k/(g_{cap}+g_{cur})$	0.51 *(2.27)**	0.53 *(2.23)**	0.56 *(2.28)**
bmp	−0.006 *(−0.74)*	0.004 *(1.13)*	0.005 *(1.22)*
Shock	0.123 *(0.82)*	0.120 *(0.89)*	0.125 *(0.97)*
Openness	0.229 *(1.11)*	0.230 *(1.14)*	0.233 *(1.18)*
(def or sur)/y	−0.237 *(−1.22)*	−0.241 *(−1.33)*	−0.254 *(−1.39)*
TR/y	0.233 *(3.12)**	0.234 *(2.94)**	0.230 *(2.82)**
NTR/y	0.133 *(1.99)**	0.129 *(1.98)**	0.130 *(2.00)**
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.132	0.128	0.126
AR(1)	(0.390)	(0.397)	(0.417)
Sargan χ^2 (r)	NA	248.6[472]	271.0[489]
Diff Sargan χ^2 (r)	NA	NA	38.8[48]
Hausman test	80.22		
Observations	267	267	267

See notes for Table 2.

Table 11 Contribution of the current component of public spending (among others) to optimal growth in the presence of three revenue-side variables in the government budget constraint

Variable	OLS (fixed effects)	GMM single	GMM system
Constant	16.26 *(2.00)**	16.19 *(2.40)**	16.17 *(2.51)**
$g_{cur}/(g_{cap}+g_{cur})$	0.20 *(2.78)**	0.18 *(2.24)**	0.17 *(2.30)**
$k/(g_{cap}+g_{cur})$	0.47 *(2.26)**	0.49 *(2.30)**	0.50 *(2.31)**
bmp	−0.005 *(−0.97)*	0.004 *(1.29)*	0.005 *(1.33)*
Shock	0.126 *(1.07)*	0.133 *(1.19)*	0.127 *(1.23)*
Openness	0.227 *(1.18)*	0.221 *(1.27)*	0.220 *(1.32)*
(def or sur)/y	−0.228 *(−1.11)*	−0.231 *(−1.20)*	−0.227 *(−1.37)*
TR/y	0.229 *(3.17)**	0.234 *(2.94)**	0.237 *(2.94)**
NTR/y	0.127 *(1.97)**	0.130 *(2.01)**	0.132 *(2.03)**
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.133	0.129	0.127
AR(1)	(0.394)	(0.402)	(0.416)
Sargan χ^2 (r)	NA	250.1[475]	270.8[487]
Diff Sargan χ^2 (r)	NA	NA	38.8[48]
Hausman test	70.94		
Observations	267	267	267

See notes for Table 2.

generally positive and significant. As regards the budget deficit/surplus variable, our results differ sharply from both Bose *et al.* (2007) and Gupta *et al.* (2005), in that in both, the budget deficit adversely affects growth, and the effect is significant; while in Adam and Bevan (2005), deficits could be growth-enhancing if financed by limited seigniorage, while they are likely to be growth-inhibiting if financed by domestic debt. The Devarajan *et al.* (1996) paper does not consider the overall budget constraint; so we cannot make a comparison with their paper.

6. Linking theory with evidence, and possible implications

Our starting point for this paper was the very interesting paper by Devarajan *et al.* (1996) which studies the link between the composition of government expenditure and long-run growth, where one component of public spending was objectively considered more productive than the other. Our paper extends the above paper both theoretically and empirically. Theoretically, we characterize OFP in terms of optimal growth, optimal productive shares, optimal tax rate, etc. The welfare maximizing levels of all the key variables of the model mentioned here can be expressed in terms of the productivities of the inputs. So, unlike Devarajan *et al.* (1996), where the factor shares are arbitrary, here the optimal factor shares are determined in terms of β and γ. We have shown analytically that $d\lambda^*/d\beta > 0$ if $\beta > \gamma$. If we go by the way the capital and current components of public spending are traditionally viewed, we would *a priori* expect the former to be more productive (i.e., the one we call g_1 with the relative productivity, β), and the latter to be less productive (i.e., the one we call g_2 with the relative productivity, γ), and expect that our econometric results would reflect that. Our empirical results, however, show that this is not the case: a rise in current spending raises the growth rate, and the opposite happens when capital spending is raised. It must then be that our *a priori* expectations about the relative productivities of current and capital components are misplaced, and g_1 ought to represent current and g_2, capital spending. Then only would the OFP story go through.

This means that some countries which followed the traditional logic of spending on (supposedly more productive) capital goods ended up with worse growth performances than those that did just the opposite, not necessarily because these countries had already overspent on such types of goods, as Devarajan *et al.* (1996) have tried to deduce, but because those goods simply did not deliver the productivity increases that were expected of them. This is typified by our finding that expenditure on health and education was found to have a negative impact on the growth rate. This could rather be due to the fact that these economies had distorted incentive structures, bureaucratic inefficiencies and/or corruption, and the fact that the goods produced from the public spending turned out to be of poor quality. The study by Tanzi and Davoodi (1997) shows, using cross-country data, that high corruption is associated with high public capital expenditures, but low operations and maintenance expenditures. This is understandable, given that the scope for indulging in corrupt practices is much higher for capital spending, given its nature.[33]

It is in general often worthwhile to spend more on the maintenance of existing infrastructure, rather than embark on new projects while the existing infrastructure is in poor condition, because this could enable full capacity utilisation and therefore more output to be generated. Leaving aside the corruption issue, this ought to be the recommendation from an efficiency standpoint, and would make the case for current rather than capital expenditure. And our empirical results for the impact of O&M expenditures on the growth rate seem to highlight precisely that point.

A point worth making is that thus far we have conducted our analysis with the implicit assumption that the government is typically utilitarian and seeks to maximize the lifetime utility of the representative agent. The fact that *ex post*, current spending turns out to be more productive could be due, in some measure, to the fact that corruption is associated with spending on new projects, and these decisions are taken by (rent-seeking) bureaucrats on behalf of the (benevolent) government.[34] If, instead of this, we assumed that the government and bureaucracy are comprised of self-interested agents who could be subsumed into one corrupt entity, as in Ellis and Fender (2006), then our analytical results could be treated as being normative rather then positive, and our empirical results would reflect a sub-optimal outcome, where the productivity of public capital is low largely due to the reasons that we have spelled out.

The findings from this study also have implications for the financing of investment projects. Corruption can contribute to tax evasion and inefficient tax administration, and therefore to low tax revenues,[35] and given the link between corruption and capital spending, there is clearly a case for advocating more current spending. And as our theoretical model shows, the more productive component of public spending (*ex post*, the current component) contributes to higher growth, thereby requiring a lower tax rate to balance the budget.[36]

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[33] The paper by Mauro (1998) provides cross-country evidence that corruption does affect the composition of government expenditure. Using corruption indices for the chosen countries, it shows that corruption reduces the spending on education, as it does not provide as many lucrative opportunities for government officials as certain other components of spending. This is mainly because its provision typically does not require high technology inputs provided by oligopolistic suppliers.

[34] In other words, some sort of principal-agent problem *à la* Acemoglu and Verdier (2000) could be at work.

[35] See, for example, Tanzi and Davoodi (1997).

[36] Having incorporated public debt into the government budget constraint via eq. (2') in Section 5.1, the interesting question as to whether the golden rule of public finance (see, for example, Buiter, 2001; Ghosh and Mourmouras, 2004, on this) - whereby borrowing by the government is permitted only to finance its capital expenditure - should be advocated for developing country governments, is a case in point.

7. Conclusion

This paper attempted to characterize OFP within an endogenous growth framework with two public goods, and one *a priori* less productive than another. The value added of our paper from a theoretical standpoint arises from characterizing optimal fiscal policy in terms of the movements of the key endogenous fiscal variables being directly linked to the productivity parameters of the model. On the empirical side, we have argued, from the methodology standpoint, that the characterisation of fiscal policy with exogenous tax rates and expenditure shares can, perhaps be better characterized by the GMM single equation method as it captures the cross-country variation in the data better than the OLS (fixed effects) method, whereas our characterisation of optimal fiscal policy (whereby, theoretically, all key variables are endogenously determined) can be captured by the GMM system (where all variables are simultaneously determined from an empirical viewpoint).

Our results have implications on how governments ought to allocate their expenditures on different types of public goods, given that if fiscal policies are pursued optimally, then expenditure shares are directly linked to productivities of these goods. Given the experiences of a number of developing countries from the three continents, it appears that the ones that have perceived correctly the productivities of the different types of public goods and allocated their expenditures in line with the productivities have done well, while those that have not done so have lost out. We have thus identified in this paper, the bias in government spending that arises in many countries due to misperceptions of governments about their priorities.

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Appendix 1: The social optimum

To characterize the social planner's problem, we first need to redefine τ and ϕ. Let τ now denote the share of total output that is devoted by the planner to the provision of the two public services, g_1 and g_2. And ϕ now denotes the share of the total expenditure on the two public goods that is devoted by the planner to the provision of the more productive public good.

Equations (1)–(5) characterize the basic model, as before. The social planner's problem is to choose c (private consumption) and $\dot{k}$ (private investment)—in addition to τ, g_1, and g_2—to maximize the representative agent's utility subject to (2), (5), and (8), taking k_0 as given.

As a result, instead of the Euler equation given by (8), we now have:

$$\lambda^{SP} \equiv \frac{\dot{c}}{c} = \frac{\partial y}{\partial k} - \rho \tag{A1}$$

Since $(\partial y/\partial g_1) = (\partial y/\partial g_2) = 1$, as for the decentralized economy, therefore we have (14)–(17), as before. So the socially optimum tax rate coincides with the optimal tax rate for the decentralized economy, and the same is true about the expenditure shares of the two public services.

As (A1) differs from (8), the expression for the economy's growth rate under the social planner will be different from that under a utilitarian government:

$$\lambda^{SP} = \frac{\alpha^{-1/\zeta}[1 - \beta^{1/(\zeta+1)} - \gamma^{1/(\zeta+1)}]^{(1+\zeta)/\zeta} - \rho}{\sigma}. \tag{A2}$$

Clearly, $\lambda^{SP} > \lambda^*$, because the social planner can internalize externalities in a way that is not possible under a decentralized economy set-up, and hence, the socially optimum growth rate is higher than the decentralized growth rate.

Appendix 2: Bias-adjusted LSDV method of estimation

Table 2a Contribution of the capital component of public spending (among others) to optimal growth

Variable	**OLS (fixed effects) corrected for small sample bias**
Constant	13.49 *(2.01)**
$g_{cap}/(g_{cap}+g_{cur})$	−0.25 *(−2.57)**
$(g_{cap}+g_{cur})/y$	0.33 *(3.02)**
$k/(g_{cap}+g_{cur})$	0.48 *(2.16)**
bmp	−0.005 *(−0.72)*
Shock	0.114 *(0.79)*
Openness	0.215 *(1.00)*
a_i	(0.00)
b_t	(0.00)
SE	0.126
AR(1)	(0.376)
Sargan χ^2 (r)	NA
Diff Sargan χ^2 (r)	NA
Observations	267

For the OLS (fixed effects) model corrected for small sample bias, AR(1) is the first order Lagrange Multiplier test for residual serial correlation. SE represents the standard error of the panel estimator. a_i and b_t are the fixed and time effects. (.) are p values, *(.)* are t statistics, *indicate significant at all conventional levels.

Table 4a Contribution of the current component of public spending (among others) to optimal growth

Variable	OLS (fixed effects) corrected for small sample bias
Constant	13.51 *(2.01)**
$g_{cur}/(g_{cap}+g_{cur})$	0.24 *(2.62)**
$(g_{cap}+g_{cur})/y$	0.35 *(3.04)**
$k/(g_{cap}+g_{cur})$	0.49 *(2.18)**
bmp	−0.006 *(−0.73)*
Shock	0.116 *(0.76)*
Openness	0.214 *(1.03)*
a_i	(0.00)
b_t	(0.00)
SE	0.124
AR(1)	(0.372)
Sargan χ^2 (r)	NA
Diff Sargan χ^2 (r)	NA
Observations	267

For the OLS (fixed effects) model corrected for small sample bias, AR(1) is the first order Lagrange Multiplier test for residual serial correlation. SE represents the standard error of the panel estimator. a_i and b_t are the fixed and time effects. (.) are p values, *(.)* are t statistics, *indicate significant at all conventional levels.