On the Composition of Government Spending, Optimal Fiscal Policy, and Endogenous Growth: Theory and Evidence

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Abstract: In an endogenous growth model with two public services with differing productivities, this paper analytically characterises optimal fiscal policy for a decentralised 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. Our theoretical results extend, and our empirical results modify those obtained by Devarajan *et al.* (1996).

Keywords: Productive and unproductive government spending, Optimal fiscal policy, Developing countries, Panel data.

JEL Classification: E62, H50, O40.

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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 effect of *productive* government spending on the growth rate becomes important. In a seminal article, 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 decentralised economy set-up, we characterise the welfare-maximising fiscal policy for a benevolent government, which chooses the fiscal instruments at its disposal to

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

[2] A recent theoretical paper by Chen (2006) 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 composition, 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.

maximise 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]

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). The authors, however, 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 (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, we can argue that countries which have correctly perceived current spending as being 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.

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[3] In Appendix A, we derive the *social optimum* as an ideal (if unrealistic) benchmark, where the social planner – in contrast to the benevolent government in a decentralised 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. 21).

[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).

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 organised as follows. Section 2 sets up the theoretical 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. Section 4 links the theoretical results with the empirical analysis. Finally, Section 5 concludes.

2.1. The Devarajan et al. (1996) model with optimal fiscal policy

In this section we first write down the key equations of the Devarajan *et al.* (1996) model, and then characterise the optimal fiscal policy (henceforth abbreviated as OFP) of the government. They 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

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

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

The government's budget constraint is

$$\tau y = g_1 + g_2 \qquad (2),$$

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

$$g_1 = \phi\tau y \quad and \quad g_2 = (1-\phi)\tau y \qquad (3),$$

where $0 \leq \phi \leq 1$.

The representative consumer's utility function is isoelastic, and derived from private consumption, 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 representative consumer's 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 given by

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

We now characterise 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 maximise 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:

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

The task of the government in a decentralised 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 maximise 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

$$\mu = \chi \tag{9},$$

$$\mu(1-\tau)\frac{\partial y}{\partial g_1} + \chi\tau\frac{\partial y}{\partial g_1} - \chi = 0 \tag{10},$$

[6] This is sometimes called in the literature, the government's 'Ramsey policy problem'. See, for instance, Bruce and Turnovsky (1999), p. 174. See also Sarte and Soares (2003), p. 41.

$$\mu(1-\tau)\frac{\partial y}{\partial g_2}+\chi\tau\frac{\partial y}{\partial g_2}-\chi=0 \qquad (11),$$

where μ and χ are the co-state variables associated with the private and government budget constraints – (5) and (2) – respectively.

From (10) and (11), we obtain $\frac{\partial y}{\partial g_1}=\frac{\partial y}{\partial g_2}=1$, from which we can obtain the optimal ratio of the two public goods when we have a benevolent government:

$$\left(\frac{g_1}{g_2}\right)^*=\left(\frac{\beta}{\gamma}\right)^{\frac{1}{\zeta+1}} \qquad (12).$$

The value of g/k is given in (6) above. Hence, using (12), we can obtain the individual values of g_1/k and g_2/k:

$$\frac{g_1}{k}=\left[\frac{(\beta/\gamma)^{(1/(\zeta+1))}}{(\beta/\gamma)^{(1/(\zeta+1))}+1}\right]\cdot\left[\frac{\tau^{\zeta}-\beta\phi^{-\zeta}-\gamma(1-\phi)^{-\zeta}}{\alpha}\right]^{1/\zeta} \qquad (13),$$

$$\frac{g_2}{k}=\left[\frac{1}{(\beta/\gamma)^{(1/(\zeta+1))}+1}\right]\cdot\left[\frac{\tau^{\zeta}-\beta\phi^{-\zeta}-\gamma(1-\phi)^{-\zeta}}{\alpha}\right]^{1/\zeta} \qquad (14).$$

From $\frac{\partial y}{\partial g_1}=1$, we obtain $\qquad g_1^{\ *}=\beta^{\frac{1}{1+\zeta}}.y \qquad$ (15),

and from $\frac{\partial y}{\partial g_2}=1$, we obtain $\qquad g_2^{\ *}=\gamma^{\frac{1}{1+\zeta}}.y \qquad$ (16).

We are now in a position to find an expression for the optimal tax rate for the decentralised economy under a benevolent government. From the government budget constraint given by (2), and given the optimal shares (of output) of the two productive inputs given by (15) and (16) above, the optimal tax rate is given by

$$\tau^*=\beta^{\frac{1}{\zeta+1}}+\gamma^{\frac{1}{\zeta+1}} \qquad (17).$$

Finally, the optimal share of the first public service from a welfare-maximising point of view is obtained by combining equations (3), (15) and (17):

$$\phi^*=\frac{\beta^{1/(\zeta+1)}}{\beta^{1/(\zeta+1)}+\gamma^{1/(\zeta+1)}} \qquad (18).$$

Clearly then, the optimal share of the second public service is obtained by combining equations (3), (16) and (17):

$$1-\phi^{*}=\frac{\gamma^{1/(\zeta+1)}}{\beta^{1/(\zeta+1)}+\gamma^{1/(\zeta+1)}} \qquad (19).$$

Combining (12), (18) and (19), we obtain the following equation:

$$\left(\frac{g_1}{g_2}\right)^{*} = \frac{\phi^{*}}{1-\phi^{*}} = \left(\frac{\beta}{\gamma}\right)^{\frac{1}{\zeta+1}} \qquad (20).$$

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 maximise the welfare of the representative agent. This optimal growth rate expression can be obtained by combining equation (7) with equations (17), (18) and (19), and is given by

$$\lambda^{*}=\frac{\alpha(1-\tau^{*})\{\alpha\tau^{*\zeta}/[\tau^{*\zeta}-\beta\phi^{*-\zeta}-\gamma(1-\phi^{*})^{-\zeta}]\}^{-(1+\zeta)/\zeta}-\rho}{\sigma}$$
$$=\frac{\alpha^{-1/\zeta}[1-\beta^{1/(\zeta+1)}-\gamma^{1/(\zeta+1)}]^{(1+2\zeta)/\zeta}-\rho}{\sigma} \qquad (21).$$

We have thus analytically characterised optimal fiscal policy in the Devarajan *et al.* (1996) model. As is clear from eqs. (17) – (21) 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 maximising 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, (ϕ*/(1-ϕ*)), 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 (β > γ).

First, from eq. (21), we find $d\lambda^*/d\beta$:

$$\frac{d\lambda^*}{d\beta} = A.B \quad , \quad where \quad A \equiv \frac{1}{\sigma}.\frac{\alpha^{-1/\zeta}}{1+\zeta}.\left(\frac{1+2\zeta}{\zeta}\right)\left[1-\beta^{1/(1+\zeta)}-\gamma^{1/(1+\zeta)}\right]^{(1+\zeta)/\zeta}, \tag{22}$$
$$B \equiv \gamma^{-\zeta/(1+\zeta)} - \beta^{-\zeta/(1+\zeta)}.$$

Clearly, $\frac{d\lambda^*}{d\beta} \; > \; 0 \quad if \quad \beta \; > \; \gamma$.

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. (17), we find $d\tau^*/d\beta$:

$$\frac{d\tau^*}{d\beta} = \frac{1}{1+\zeta}\left[\frac{1}{\beta^{\zeta/(1+\zeta)}} - \frac{1}{\gamma^{\zeta/(1+\zeta)}}\right]. \tag{23}$$

Clearly, $\frac{d\tau^*}{d\beta} \; < \; 0 \quad if \quad \beta \; > \; \gamma$.

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-maximising perspective, an increase in the productivity of the more productive public good leads to a fall in the optimal tax rate.

[7] As we shall see later, empirically it turns out that the current – rather than capital – component of expenditure is the more productive; so 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.

Finally, from eq. (20), we find d(ϕ*/(1-ϕ*))/dβ:

$$\frac{d\,(\phi^*/(1-\phi^*))}{d\beta} = \frac{C}{D},$$
$$\text{where} \quad C \equiv \frac{1}{1+\zeta}\left[\left(\beta^{-\zeta}\gamma\right)^{1/(1+\zeta)} + \left(\beta\gamma^{-\zeta}\right)^{1/(1+\zeta)}\right], \quad D \equiv \gamma^{2/(1+\zeta)}. \tag{24}$$

Clearly, $\frac{d\left(\phi^*/\left(1-\phi^*\right)\right)}{d\beta} \succ 0 \;$ if $\; \beta+\gamma \succ 0.$

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

Having derived the comparative statics results analytically, we proceed to find numerically how the optimal values of (λ, τ, ϕ) change with changes in β. The numerical simulations are reported in Table 1.

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

α	β	γ	λ*	τ*	ϕ*
0.25	0.40	0.35	-0.00985	0.8829	0.5278
0.25	0.50	0.25	-0.00977	0.8762	0.6405
0.25	0.60	0.15	-0.00944	0.8591	0.7605
0.25	0.70	0.05	-0.00745	0.8252	0.9002
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
0.75	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: ζ = 0.2, σ = 2, ρ = 0.02.

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*. In this context, we do not include government consumption that *directly* affects utility, as in Barro (1990), Section V, or as suggested by Aschauer and Greenwood (1985). For one thing, we are interested in government expenditure that directly affects production rather than utility.[8] For another, the former can be appropriately distinguished from productivity-augmenting government expenditure from the functional definition of government spending. 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 of 48 US states. While the *economic* rather than *functional* classification of expenditure[9] is considered in this paper, investment in public education is viewed as productive, and the same applies to health, while defence spending is considered unproductive, although Barro (1991) considers it productive as it helps protect property rights. Consequently, education and health would typically be part of government capital expenditure, while defence would be a component of current expenditure.

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 during the period, 1990-2000, Gupta *et al*. (2005) show that fiscal

[8] This is why our OFP analysis differs from Chen (2006).

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

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 more productive (i.e., capital) 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[10] from 1972 to 1999, to examine the link between components of government expenditure and growth from a welfare-maximising perspective.[11] We use annual data obtainable from the Global Development Network Growth Database compiled by William Easterly.[12]

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

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

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

The model in Section 2 linked growth with shares from an OFP perspective: clearly, from eq. (21), the optimal growth rate, λ^* is linked to the parameters, α, β, γ, σ and ρ, and as eq. (22), 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.

Finally, as in Devarajan *et al.* (1996), the 'black market premium' variable captures the effects of other domestic policies (i.e., other than productive public spending) in countries that also affect the growth rate. This variable, obtained from the Easterly database, is the premium on the official rate in the black market for foreign exchange.

The dependent variable is chosen as the per capita real GDP growth rate in the first set of regressions (Table 2). To account for the lag between the spending on public goods and the effect on output growth, we use a five year forward moving average 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 panel data. This is provided in Table 3. As pointed by Devarajan *et al.* (1996), the five year forward lag structure addresses the joint endogeneity of variables and the possibility of reverse causality.[13] In a sense, the joint endogeneity of public expenditure and growth is an issue that should be taken more seriously in our framework, given that we are considering OFP where, in theory, these variables are, indeed, determined jointly.

[13] See Devarajan *et al.*, p. 322 for details.

The model specification for the first set of regressions is:

$$G_{it} = a_i + b_t + f_1\left(\frac{g_{1,it}}{g_{1,it} + g_{2,it}}\right) + h\left(\frac{g_{1,it} + g_{2,it}}{y_{it}}\right) + j\left(\frac{k_{it}}{(g_{1,it} + g_{2,it})/y_{it}}\right) + l(bmp_{it})$$
$$+e_{it}$$

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_1 is ‘capital expenditure’, and g_2 is ‘current expenditure’, both from the ‘Government Finance’ account in the Easterly database, y is GDP at market prices, k is the gross fixed capital formation as a percentage of GDP, and bmp is the black market premium.

The model specification for the second set of regressions is:

$$G_{it} = a_i + b_t + f_2\left(\frac{g_{2,it}}{g_{1,it} + g_{2,it}}\right) + h\left(\frac{g_{1,it} + g_{2,it}}{y_{it}}\right) + j\left(\frac{k_{it}}{(g_{1,it} + g_{2,it})/y_{it}}\right) + l(bmp_{it})$$
$$+e_{it}$$

We use the classification of government expenditure used in the Easterly database. In line with the theoretical model, we have the share of current spending as a proportion of total public spending as the first explanatory variable the ratio of total public spending to output as the second variable and the ratio of capital-output ratio to government spending-output ratio.[14]

3.2. *Methodology*

Though the OLS fixed effects model captures the effects of fiscal policy when the tax rate and government expenditure shares are exogenously given, 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. However, for the OFP exercise, we feel that the GMM

[14] Note that the Easterly database provides data on gross fixed capital formation as a percentage of GDP, while g_1 and g_2 refer to capital and current spending at market prices respectively; so (g_1 + g_2) has to be divided by y to make units comparable.

system is probably the ideal methodology to capture the endogeneity involved in the joint determination of the key variables (ϕ^*, λ^*, τ^*) in the theoretical model.[15] 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 endogeneity 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.[16]

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

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[15] 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. (21), λ^* (optimal λ) is expressed in terms of τ^* (optimal τ - endogenous) and ϕ^* (optimal ϕ - endogenous).

[16] 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.

$$E\left(G_{i,t-z}\Delta e_{it}\right)=0 \text{ for } z\geq 2; \quad t=3,.......,T.$$

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

$$E\left(X_{i,t-z}\Delta e_{it}\right)=0 \text{ for } z\geq 2; \quad t=3,.......,T.$$

The single equation GMM panel estimator generally specifies a dynamic panel model in first differences and exploits the above moment conditions.[17] Therefore, the lagged (two 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 $z\geq 2$). The first set of transformed equations continues to use the lag levels as instruments. The level equation on the other hand, use the lagged first differences as instruments. Their validity is based on the following moment conditions:[18]

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

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

[17] The model is transformed into first differences in order to eliminate the fixed effects.
[18] The time-varying matrix of instruments for the first difference GMM estimator can be observed in Blundell and Bond (1998).

Bond *et al*. (2001) show that the system GMM estimator performs better then a range of other method of moment type estimators. 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. ***Econometric estimates***

$$G_{it} = a_i + b_t + f_1\left(\frac{g_{1,it}}{g_{1,it}+g_{2,it}}\right) + h\left(\frac{g_{1,it}+g_{2,it}}{y_{it}}\right) + j\left(\frac{k_{it}}{(g_{1,it}+g_{2,it})/y_{it}}\right) + l(bmp_{it})$$
$$+e_{it}$$

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

Variable	OLS (fixed effects)	GMM Single	GMM System
Constant	13.49(**2.01**)*	13.44(**2.39**)*	13.43(**2.41**)*
g1/(g1+g2)	-0.25(**-2.57**)*	-0.18(**-2.14**)*	-0.17(**-2.19**)*
(g1+g2)/y	0.33(**3.02**)*	0.36(**2.92**)*	0.39(**2.77**)*
k/((g1+g2)/y)	0.48(**2.16**)*	0.51(**2.24**)*	0.52(**2.29**)*
bmp	-0.005(**-0.72**)	0.007(**1.09**)	0.008(**1.05**)
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.126	0.126	0.126
AR(1)	(0.376)	(0.389)	(0.433)
Sargan $\chi^2(r)$	NA	248.9[473]	271.2[490]
Diff Sargan $\chi^2(r)$	NA	NA	38.9[48]
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 endogenous explanatory variables in the panel are GMM instrumented setting $z \geq 3$. (.) are p values, **(.)** are t statistics, * indicate significant at all conventional levels.

The table below represents the model above with the use of the five-year forward moving average of growth rather then growth itself.

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

Variable	OLS (fixed effects)	GMM Single	GMM System
Constant	13.48(**2.02**)*	13.46(**2.46**)*	13.44(**2.71**)*
g1/(g1+g2)	-0.27(**-2.31**)*	-0.20(**-2.11**)*	-0.18(**-2.14**)*
(g1+g2)/y	0.35(**3.11**)*	0.37(**2.25**)*	0.38(**2.43**)*
k/((g1+g2)/y)	0.45(**2.17**)*	0.48(**2.25**)*	0.50(**2.29**)*
bmp	-0.003(**-0.74**)	0.005(**1.08**)	0.006(**1.03**)
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.126	0.126	0.125
AR(1)	(0.374)	(0.387)	(0.430)
Sargan $\chi^2(r)$	NA	253.7[475]	274.3[492]
Diff Sargan $\chi^2(r)$	NA	NA	39.6[49]
Observations	267	267	267

See notes for Table 2.

$$G_{it} = a_i + b_t + f_2\left(\frac{g_{2,it}}{g_{1,it} + g_{2,it}}\right) + h\left(\frac{g_{1,it} + g_{2,it}}{y_{it}}\right) + j\left(\frac{k_{it}}{(g_{1,it} + g_{2,it})/y_{it}}\right) + l(bmp_{it})$$

$$+e_{it}$$

TABLE 4. Contribution of the *current* component of public spending (among others) to optimal growth

Variable	OLS (fixed effects)	GMM Single	GMM System
Constant	13.51(**2.01**)*	13.48(**2.39**)*	13.46(**2.41**)*
g2/(g1+g2)	0.24(**2.62**)*	0.20(**2.17**)*	0.19(**2.22**)*
(g1+g2)/y	0.35(**3.04**)*	0.37(**2.93**)*	0.40(**2.79**)*
k/((g1+g2)/y)	0.49(**2.18**)*	0.53(**2.27**)*	0.52(**2.31**)*
bmp	-0.006(**-0.73**)	0.008(**1.11**)	0.007(**1.06**)
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.124	0.124	0.123
AR(1)	(0.372)	(0.383)	(0.425)
Sargan $\chi^2(r)$	NA	248.6[472]	270.9[488]
Diff Sargan $\chi^2(r)$	NA	NA	38.6[48]
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 endogenous explanatory variables in the panel are GMM instrumented setting $z \geq 3$. (.) are p values, **(.)** are t statistics, * indicate significant at all conventional levels.

The table below represents the model above with the use of the five-year forward moving average of growth rather then growth itself.

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

Variable	OLS (fixed effects)	GMM Single	GMM System
Constant	13.49(**2.03**)*	13.48(**2.48**)*	13.46(**2.72**)*
g2/(g1+g2)	0.26(**2.30**)*	0.22(**2.14**)*	0.19(**2.15**)*
(g1+g2)/y	0.34(**3.12**)*	0.35(**2.26**)*	0.39(**2.44**)*
k/((g1+g2)/y)	0.47(**2.19**)*	0.49(**2.26**)*	0.52(**2.27**)*
bmp	-0.004(**-0.76**)	0.007(**1.09**)	0.008(**1.05**)
a_i	(0.00)	(0.00)	(0.00)
b_t	(0.00)	(0.00)	(0.00)
SE	0.125	0.125	0.126
AR(1)	(0.382)	(0.394)	(0.426)
Sargan $\chi^2(r)$	NA	252.8[475]	273.2[491]
Diff Sargan $\chi^2(r)$	NA	NA	39.4[49]
Observations	267	267	267

See notes for Table 4.

3.4. *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. In addition, all estimated models pass the diagnostic tests.[19] A test for first order residual serial correlation is insignificant which suggests that the panels do not suffer from serial correlation. Sargan tests confirm the validity of the instruments in both GMM models.[20]

Table 2 shows that there is a *negative* and statistically significant relationship between the capital component of 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.[21] From the OLS fixed effects model, we find that a unit increase in the

[19] We used three lags in our estimations, but also experimented with other lag structures. Our results are robust to 1, 2 and 4 lags. These results are obtainable upon request.

[20] 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.

[21] 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.

ratio of capital to total spending decreases per capita real GDP growth by 25 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 (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 0.50 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. It means 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-maximising 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.

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 1, 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 $g_2/(g_1+g_2)$ 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)). In the OLS fixed effects model specification, a unit increase in the $g_2/(g_1+g_2)$ ratio increases per capita real GDP growth by 24 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.

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.

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 bias 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.[22] 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 B. As we can see, the OLS fixed effects results

[22] We thank Jonathan Temple for suggesting the use of Kiviet's bias-adjusted LSDV estimator.

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.[23]

4. *Linking theory under OFP with evidence, and possible implications*

Our starting point for this paper was the very interesting paper by Devarajan *et al.* (1996) on 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. However, this component could actually be less productive if its initial share (which is given arbitrarily) in the production function was too high. From the empirical evidence it was found that capital expenditures, which are generally assumed to be more productive, turn out to have a negative impact on growth, while current expenditures, usually considered less productive, have a positive impact on growth.[24] This suggests that countries with an initially large (small) share of the objectively more productive component turn out to be less (more) productive at the margin.

Our paper extends the above paper both theoretically and empirically. Theoretically, we characterise OFP in terms of optimal growth, optimal productive shares, optimal tax rate, etc. The welfare maximising 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 theoretically 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. The empirics, however, show that this is <u>not</u> the case: a rise in current spending raises the growth rate, and the opposite

[23] 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.

[24] Note that Evans and Karras (1994) found fairly strong evidence that current government educational services are productive, but no evidence that the other government activities they considered are productive. In fact, they typically found negative productivity for government capital, and therefore, could not conclude that the US as a whole suffers from an infrastructure crisis – on the contrary, their study reveals that there could well have been an overprovision of government capital in the US.

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 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 could 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.[25]

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.

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 maximise 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

[25] 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.

by (rent-seeking) bureaucrats on behalf of the (benevolent) government.[26] 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 spelt 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,[27] 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.[28]

5. *Conclusion*

This paper attempted to characterise OFP within an endogenous growth framework with two public goods, and one *a priori* less productive than another. From the theoretical model, we found out analytical expressions for the key variables like the optimal growth rate, optimal productive shares and optimal tax rate, and these were directly linked to the productivities of the two public goods in the production function. Judging by the way the components of public spending are traditionally viewed, we expected the capital (current) component to affect growth positively (negatively). But our empirical analysis using the OLS (fixed effects) model, the GMM single equation framework and the GMM system, all showed the reverse, i.e., the capital component affected growth negatively, contrary to *a priori* expectations. Our results are in accordance with the results obtained by Devarajan *et al*. (1996), although the value added of our paper from a theoretical standpoint arises from

[26] In other words, some sort of principal-agent problem *a la* Acemoglu and Verdier (2000) could be at work.
[27] See, for example, Tanzi and Davoodi (1997).
[28] If eq. (2) of our model were modified to incorporate public debt, then 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.

characterising optimal fiscal policy, something that the authors have suggested as a future extension. On the empirical side, we have argued that the Devarajan *et al.* (1996) characterisation of fiscal policy with exogenous tax rates and expenditure shares can, perhaps be better characterised 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 jointly 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. While Devarajan *et al.* (1996) have identified the bias in government spending in many countries, and linked this to spending on items that have already been excessively provided, we have identified the bias in terms of misperception of governments about their priorities.

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Appendix A: The Social Optimum

To characterise 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.

Eqs. (1) – (5) characterise the basic model, as before. The social planner's problem is to choose c (private consumption) and dk/dt (private investment) – in addition to τ, g_1 and g_2 – to maximise the representative agent's utility subject to (2), (5) and (8), taking k_0 as given. The first order conditions with respect to c and k respectively, yield

$$\mu = c^{-\sigma}.e^{-\rho t} \qquad \text{(A1)},$$

$$\mu(1-\tau)\frac{\partial y}{\partial k} + \chi\tau\frac{\partial y}{\partial k} = -\dot{\mu} \qquad \text{(A2)}.$$

The first order conditions with respect to τ, g_1 and g_2 respectively, yield (9) – (11), as previously obtained.

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

$$\rho + \frac{\dot{c}}{c} = \frac{\partial y}{\partial k} \qquad \text{(A3)}.$$

Since $\frac{\partial y}{\partial g_1} = \frac{\partial y}{\partial g_2} = 1$, as for the decentralised economy, therefore we have (17) – (20), as before. So the socially optimum tax rate coincides with the optimal tax rate for the decentralised economy, and the same is true about the expenditure shares of the two public services.

As (A3) differs from (8), the expression for the economy's growth rate under the social planner will be different from that under a utilitarian government:

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

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

Appendix B: 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**)*
g1/(g1+g2)	-0.25(**-2.57**)*
(g1+g2)/y	0.33(**3.02**)*
k/((g1+g2)/y)	0.48(**2.16**)*
bmp	-0.005(**-0.72**)
a_i	(0.00)
b_t	(0.00)
SE	0.126
AR(1)	(0.376)
Sargan $\chi^2(r)$	NA
Diff Sargan $\chi^2(r)$	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**)*
g2/(g1+g2)	0.24(**2.62**)*
(g1+g2)/y	0.35(**3.04**)*
k/((g1+g2)/y)	0.49(**2.18**)*
bmp	-0.006(**-0.73**)
a_i	(0.00)
b_t	(0.00)
SE	0.124
AR(1)	(0.372)
Sargan $\chi^2(r)$	NA
Diff Sargan $\chi^2(r)$	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.