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Economic growth with an optimal public spending composition

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This paper uses a one-sector, endogenous growth model to study optimal composition between public investment and consumption in government expenditure and its relationships with economic growth. Assuming a benevolent government which maximizes a representative household's lifetime utilities, the paper determines the unique, interior public investment share in government's budgets, which is determined by policy and structural parameters, and finds that the conventional determinants of economic growth now generate stronger growth effects, via their indirect impacts upon optimal public spending composition. The effects emerge from raising the marginal utility of private consumption, relative to the marginal utility of public consumption, thereby inducing public investment and increasing economic growth. Our quantitative results suggest that the growth effect is sizable. The large growth effect via optimal public investment in our model has implications for East Asian economic growth miracles where public investment share and economic growth are both higher than other area's countries.

JEL classification: H41, H54, O41.

1. Introduction

Since the publication of the journal article by Barro (1990), growth effects of public spending have been one of the popular topics in economic research.[1] Existing endogenous growth models specify public spending either as being productive or as consumptive. While productive public spending is formulated to externally enhance production, consumptive public spending is devised to externally increase households' utility. Recent works such as Futagami, *et al.* (1993), Glomm and Ravikumar (1994), Fisher and Turnovsky (1998), and Chen (2003) have adopted the former specification, while other studies like Bianconi and Turnovsky (1997) and Devereux and Wen (1998) have used the latter strategy. Moreover, some

[1] See other research on fiscal policy on the growth effects of taxation, made popular by Lucas (1990), including Rebelo (1991), Turnovsky (1996), Bond, *et al.* (1996), and Mino (1996), among others.

analyses have included both aspects of public spending, e.g., Baxter and King (1993) and Chang (1999).

The composition between consumptive and productive spending in government differs substantially across countries.[2] Moreover, the countries with a larger share of productive public spending have reached higher growth, while the countries with a smaller share have attained lower growth. Although a large share of productive public spending is associated positively with economic growth, the question is why some governments would choose a large fraction of productive spending while others choose a small share. How does a government determine the composition between consumptive and productive expenditure, optimally? What are the relationships between the determinants of public spending composition and economic growth? These are important questions, as their answers may uncover underlying factors enhancing long-run economic growth through a higher optimal productive spending share in government, a mechanism that has not been fully disclosed by existing works. This paper envisages these questions in a simple, one-sector endogenous growth model.

In this model, the government decides optimal spending composition under given income tax rates, in order to maximize representative households' lifetime utilities. Given the optimal composition, representative households then optimize consumption/savings choices. We show the existence of unique, interior optimal composition in public spending, with the composition being determined by all policy and other structural parameters. These factors raise the marginal utility of private consumption, relative to the marginal utility of public consumption, allowing governments to allocate fewer monies for consumptive spending and allocate more for productive spending at optimum thereby yielding stronger and sizable positive long-run growth effects in equilibrium, than would be otherwise conventionally obtained.

Lee (1992) and Baier and Glomm (2001) note that the stock of productive public services accumulates over time. Although Lee analyses optimal shares of public spending among productive services, consumptive services, and transfers, his main purpose is to derive two optimal sizes of government, with the results that different sizes of government lead to different shares of productive public services, resulting in different economic growth rates. Our work differs from Lee in that the optimal share of public services, and thus economic growth, is determined by policy and all demand- and supply-sided factors, but is only influenced by the degree of public capital on production as noted by Lee. Baier and Glomm (2001) study the steady-state, optimal public expenditure between consumptive

[2] The share of productive public spending is higher in East Asian countries, lower in North American and European countries, and much lower among Latin American countries. For example, in the 1980s and early 1990s the share was above 15% in Korea and above 20% in Taiwan, a little more than 5% in the US and nearly 5% in the UK and France. Brazil was less than 5%. See the IMF (various years) and the CEPD (2001).

and productive services in a model where their work is mainly to quantify the welfare effect of taxation reforms in transitions and steady state under different setups for production technology. Our work differs from Baier and Glomm (2001) in that we explicitly take into account the instantaneous response of consumption when the government optimizes public expenditure composition which has not been incorporated in Baier and Glomm. More importantly, with the response via the optimization of public expenditure composition, we have found larger growth effects for the determinants of economic growth than those in otherwise identical frameworks examined by Lee (1992) and Baier and Glomm (2001).

Cazzavillan (1996), Raurich (2003), and Park and Philippopoulos (2004) have considered public expenditure affecting either utility or production. Each of these papers focuses upon local indeterminacy. The condition for local indeterminacy found in Cazzavillan (1996) is for the felicity to exhibit increasing returns in consumption and public consumption. In Raurich (2003), an endogenous labor supply is considered and local indeterminacy emerges if the effect of an increase in labor supply on the change of labor supply over time is positive. Park and Philippopoulos (2004) consider monopolistic competition in the goods market and find local indeterminacy because of the wedge between the rate of returns that determines the stream of income and the rate of returns that drive consumption/savings decisions. In our paper, neither a felicity with increasing returns in consumption and public services nor endogenous labor supply and monopolistic competition in the goods sector are considered, thus we do not obtain local indeterminacy.[3]

Finally, this paper differs from and contributes to previous papers in the following perspectives. We obtain a general form for the determinants of optimal public spending shares: the optimal share of productive public services is determined by policy, supply- and demand-side, economic structural factors. More importantly, we investigate how changes in underlying structural factors affect economic growth through governments' response to its changing productive and consumptive share, entailing a growth mechanism that has never been fully studied. This paper demonstrates steady-state growth effects of changes in underlying policies and economic structures which are stronger than those otherwise obtained from existing endogenous growth models.

[3] There are other lesser related works, including Lau (1995), Devarajan, *et al.* (1996), Turnovsky (2000), and Piras (2001). While Lau (1995) compares the differences of optimal public investment share and public consumption shares under growth-maximization and welfare-maximization, Devanrajan, *et al.* (1996) assume two kinds of public investment without public consumption and test their model using data for developing countries. Turnovsky (2000) extends Barro (1990) to consider elastic labor supply and finds many different growth effects due to labor supply responses, and Piras (2001) studies the effect of public consumption congestion upon economic growth and public investment shares. These last two papers find that the optimal investment shares depend only upon the degree of public capital externality.

As developed below, Section 2 sets up the framework. While Section 3 studies optimal public spending compositions, Section 4 investigates the relationships between optimal compositions and economic growth. Section 5 offers a conclusion.

2. A basic model

Our model differentiates productive public spending from consumptive public spending. We follow Barro (1990) by assigning public consumption entering households' instantaneous utilities, and productive public services entering private production in an external fashion.[4] The economy is populated by a continuum of infinitely-lived, representative households, with its size constant and normalized to be unity. There is a continuum of representative firms, each with a production technology and households entitle its shares. In addition, there is a government.

A representative household possesses lifetime utility: $U = \int_0^\infty e^{-\rho t} \times [(c(t)^\alpha g_c(t)^{1-\alpha})^{1-\sigma} - 1]/(1-\sigma)\mathrm{d}t$, in which $c(t)$ is the consumption in t, and $g_c(t)$ is public consumption. Parameter $\rho > 0$ is the instantaneous time-preference rate, $0 < \alpha < 1$, is the share of consumption in households' utility, relative to public consumption, and σ is the reciprocal of the intertemporal elasticity of substitution for consumption. We assume $1 - \sigma < 1$ so the instantaneous felicity function is strictly concave in its arguments. The production technology is $y(t) = Ak(t)^\beta g_I(t)^{1-\beta}$, in which $y(t)$ is the output *per capita*, $k(t)$ is the capital stock *per capita*, and $g_I(t)$ is the productive public service *per capita* in t. Parameter $A > 0$ is the productivity level and $0 < 1-\beta < 1$ captures the externality of public services upon production. For simplicity, we assume zero depreciation for capital stock. Each firm is competitive in the goods and input markets.

Since the government provides both public consumptive and productive services free of charge, it is necessary to have sources of tax revenues. We assume that public spending is financed by income taxes. An income tax setup generates tax revenues consistent with a perpetual growth framework, and has been employed by Barro (1990) and his followers. Then, households' and government's budget constraints are noted as $T(t) = \tau y(t) = g_c(t) + g_I(t) = s\tau y(t) + (1-s)\tau y(t)$, and $\dot{k} = (1-\tau)y(t) - c(t)$, respectively, in which τ is the income tax rate, and $s(1-s)$ is the fraction of public consumption (services) in government tax revenues, $T(t)$.

Using the above setup, we derive the optimization conditions, and obtain equilibrium with a balanced growth path (BGP), $\dot{k}/k = \dot{c}/c = \dot{y}/y = \dot{g}_c/g_c = \dot{g}_I/g_I$, referred to as ϕ (see the Appendix).

$$\phi = \left[(1-\tau)A^{1/\beta}\tau^{(1/\beta-1)^2}\beta(1-s)^{1/\beta-1} - \rho\right]/\sigma \tag{1}$$

[4] Early works modeling public capital as a factor of production include Shell (1967) and Arrow and Kurz (1970). Empirically, a positive effect of public capital on production has recently been documented by Aschauer (1989) in a study using the US data. Lynde and Richmond (1993) find that public capital has played an essential role in enhancing the productivity growth of UK manufacturing. See Gramlich (1994) for a survey of the empirical literature, most of which is for the US.

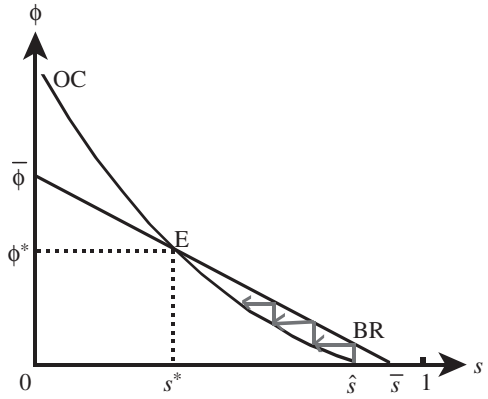

Fig. 1. Optimal government expenditure composition

Differentiation of (1) indicates that economic growth is decreasing in the share of public consumption in government spending, because the share helping production is reduced. (See the Appendix available upon request, for the comparative statics). Moreover, other things being equal, it is easy to show that economic growth increases in A and β because of the resulting higher marginal productivity of capital, and decreases in τ, σ and ρ because of lower accumulation of capital resulting from either a lower disposable income due to higher tax rates or a higher consumption level due to a lower intertemporal elasticity of substitution and a higher time-preference rate. In a (s, ϕ) plane in Fig. 1, it is denoted as Locus BR (best response), downward slopping, with intersection at $0 < \bar{s} = 1 - [\rho(1-\tau)^{-1}\tau^{-(1/\beta-1)^2} \times \beta^{-1}A^{-1/\beta}]^{\beta/(1-\beta)} < 1$.

3. Optimal government expenditure composition

We now proceed to the main body of this paper with this section analysing the second-best optimization problem while the next section investigates the relationship between optimal composition and economic growth. We assume a benevolent government which maximizes the present discounted value of a representative household's utility by choosing a public spending composition, given production technology, resource constraints, and the individuals' best responses, summarized in (1). The government's problem becomes one of maximizing the representative household's utility subject to (1).

The optimization leads to the following relationship, and total differentiation yields the results of the comparative statics in Proposition 1.

$$\sigma(1-\alpha)\left(\frac{1}{s}-\frac{1}{\beta}\right) = \left(\frac{1}{\beta}-1\right)(\sigma\phi+\rho)\left(\frac{1}{\sigma\phi+\rho-\phi}+\frac{\left(\sigma\tau^{(1/\beta-1)(2-1/\beta)}-\beta\right)\alpha}{(\sigma\phi+\rho)\tau^{(1/\beta-1)(2-1/\beta)}-\beta\phi}\right). \tag{2}$$

Proposition 1 The optimal fraction of public consumption in government spending is characterized by $s = s(\phi; \tau, \beta, \alpha, \sigma, \rho)$, $s_\phi < 0$, $s_\tau < 0$, $s_\beta > 0$, $s_\alpha < 0$, $s_\sigma > 0$, $s_\rho > 0$.

Proof See the Appendix.

The intuition behind Proposition 1 is as follows. The optimal fraction of public consumption decreases in the economic growth rate because a higher economic growth increases the marginal cost of current consumption and thus the optimal fraction of public consumption needs to be reduced in order to increase the marginal utility. Moreover, the optimal fraction in public consumption decreases in τ and α. A higher income tax rate reduces disposable income and consumption, and thus, increases the marginal utility of private consumption, and optimally, the government reduces the share of public consumption in government spending in order to raise the marginal utility of public consumption. Similarly, a larger share of private consumption in utility directly increases the marginal utility of private consumption and decreases the marginal utility of public consumption, and optimally, the share of public consumption is reduced.

Alternatively, the optimal fraction in public consumption increases in β, σ, and ρ, because a larger share of private capital in production increases the marginal product of private capital, and thus income, that increases private consumption leading to a lower marginal utility of private consumption. In order to reduce the marginal utility of public consumption, the government optimally decreases the share of productive public service and increases the share of public consumption. Finally, a smaller intertemporal elasticity of substitution and a larger time-preference rate both lower the marginal utility of future private consumption, and therefore, the government optimally increases the share of public consumption in government spending, in order to reduce the marginal utility of public consumption.

In a (ϕ, s) plane in Fig. 1, relationship (2) is referred to as Locus OC (optimal composition), which is downward slopping, with a very large slope when s is very small and with

$$\hat{s} = \frac{\beta\sigma(1-\alpha)}{\sigma(1-\alpha) + (1-\beta)\left[1 + \alpha - \alpha\beta\tau^{(1/\beta-1)(2-1/\beta)}\right]} < 1 \quad \text{when } \phi = 0.$$

Thus, (1) and (2) together determine the optimal public consumption share and the economic growth rate in a BGP. In order to assure the existence of an interior optimal public consumption share, it is required that $\hat{s} < \bar{s}$ according to Fig. 1,

which is equivalent to:

$$\textit{Condition } S: \frac{\beta\sigma(1-\alpha)}{\sigma(1-\alpha)+(1-\beta)\left[1+\alpha-\alpha\beta\tau^{(1/\beta-1)(2-1/\beta)}\right]} < 1-\left[\frac{\rho}{(1-\tau)\tau^{(1/\beta-1)^2\beta A^{1/\beta}}}\right]^{\beta/(1-\beta)}$$

which for a small ρ is easily met. The condition requires the optimal share of public consumption under zero economic growth leads to positive equilibrium economic growth in order for the government to respond by reducing the optimal share of public consumption, as indicated by arrows in Fig. 1. To summarize:

Proposition 2 Under Condition S, there exists an interior, optimal share of productive public services in government spending in a BGP with a positive economic growth rate.

4. Optimal composition and economic growth

As the composition of public spending is optimized, the optimal share of productive public services, is determined not only by the degree of public capital externality, but also by all the underlying policy and other structural parameters in (1) and (2). Thus, parameters underlying policies and economic structure tend to affect economic growth through public spending compositions. This section investigates how these factors influence the optimal public spending composition and the resulting growth effects. The factors can be classified into three aspects, and we start with the size of government, followed by supply-side factors, and finally, by demand-side factors.

4.1 Sizes of government

The size of government here is represented by the average income tax rate τ. Most cross-country studies find that economic growth tends to be negatively associated with the size of public consumption (e.g., Barro and Sala-i-Martin, 1995). It is interesting to analyse how the size of government affects the optimal public spending composition, and the consequent effects upon economic growth.

A larger size of government may shift the Locus BR upwards or downwards, depending upon the initial government size relative to the threshold $\hat{\tau} = (1/\beta - 1)^2/(1 + (1/\beta - 1)^2)$, the optimal tax rate that would maximize economic growth, and thus welfare, in an otherwise identical economy without the optimal public expenditure composition (e.g., Barro, 1990). When tax rates are higher than the threshold, the initial government size is large so a larger government size shifts the Locus BR downwards to $B'R'$ (in Fig. 2), which for a given s, reduces economic growth (E_1). Moreover, when there is a higher tax rate, and thus a larger size of government, the resulting lower private consumption increases the

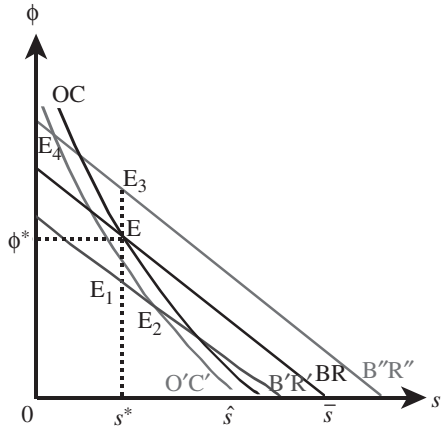

Fig. 2. Effects of a larger size of government

marginal utility, and as a result the government optimally decreases the share for public consumption in order to reduce the marginal utility of public consumption. Therefore, the Locus OC shifts leftward (see $O'C'$), thus making economic growth decrease further (E_2).

Alternatively, when the initial government size is below the threshold, an increase in the size of the government shifts Locus BR upwards to $B''R''$ which for a given s, increases economic growth (E_3). As a smaller optimal share of public consumption is accompanied, Locus OC shifts leftward towards $O'C'$ and therefore, economic growth is increased further (E_4).

Proposition 3 Suppose the government optimizes its spending composition. When the initial government size is above (below) the tax rate threshold that would maximize the welfare in an otherwise identical framework without optimizing public spending composition, the negative (positive) growth effect of increasing the government size is larger than the case of unresponsive public spending composition.

4.2 Supply-side factors

The supply-side factors here include the productivity and the capital share. When the productivity is higher (a higher A), the Locus BR shifts upwards to $B'R'$ in Fig. 3. Thus, equilibrium changes from E to E_1, and as a result, economic growth increases, as in existing literature (e.g., Barro, 1990). Moreover, as economic growth increases, the government is induced to optimally reduce the public consumption share indirectly (along Locus OC), thereby moving equilibrium to E_2 and enhancing economic growth further.

Intuitively, higher productivity increases the marginal productivity of capital, leading to a direct growth effect, and resulting in higher discounted marginal utility

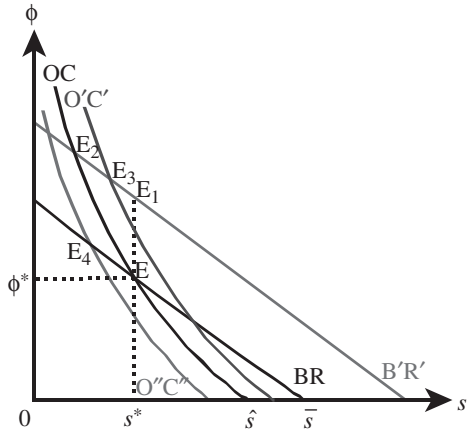

Fig. 3. Effects of higher A, β and α

from future consumption. The government therefore, optimally reduces public consumption shares, in order to increase the marginal utility of public consumption. Productive public service shares are thus increased which complements the productivity of capital and leads to faster capital accumulation in a steady-state equilibrium. This allows for the economy to grow even more rapidly.

Similarly, a higher capital share in production (a higher β) shifts the Locus BR upward to B′R′ in Fig. 3, just as the case of higher productivity. Under given government spending composition, equilibrium changes from E to E_1, resulting in higher economic growth. As the degree of public service externality is smaller (i.e., a lower $1-\beta$), for a given economic growth rate the government reduces the share of productive public service, thus shifting the Locus OC rightward to O′C′. Nevertheless, higher economic growth indirectly induces the government to reduce the share of public consumption, so the net effect depends upon whether the direct or the indirect effect dominates. Therefore, economic growth may be enhanced or mitigated. As our calibration suggests, the indirect effect quantitatively dominates the direct effect, and therefore, the share of public consumption is reduced, and the economic growth rate is increased further (see E_3).

Proposition 4 Higher productivity results in a lower consumption share in public spending, thereby leading to a stronger growth effect than the case of exogenous or unresponsive public spending compositions. Higher capital shares have similar effects when the indirect effect dominates.

4.3 Demand-side factors

There are three demand-side parameters. First, when the consumption share is higher (a higher a), relative to public consumption, the Locus BR is not affected. Nevertheless, the Locus OC shifts leftward to O″C″ (see Fig. 3), because a higher

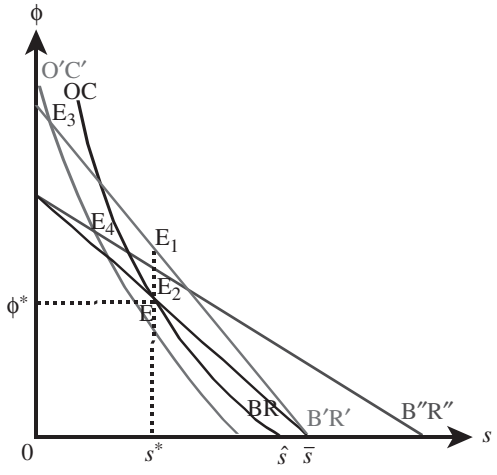

Fig. 4. Effects of lower σ and ρ

consumption share reduces the marginal utility of public consumption and increases the marginal utility of consumption, and thus the government optimally raises productive public services and lowers consumptive service, driving a leftward shift of the Locus OC and thereby relocating equilibrium from E to E_4. As a result, optimal public consumption shares decrease and economic growth increases. This indirect positive growth effect differs from those in conventional wisdom. For example, a higher consumption share does not have any direct or indirect growth effect in Barro (1990), and a higher consumption share causes a direct negative growth effect in Turnovsky (1996, 2000) and a direct, but not an indirect, positive growth effect in Piras (2001).[5] These differences lie in the situation that the government in our model optimally increases the share of productive public service in reaction to a higher share of consumption, which complements capital formation and thereby enhances economic growth.

Finally, higher intertemporal elasticity of substitution in consumption (a lower σ) and lower time-preference rates (a lower ρ) both increase the growth rate of consumption, shifting the Locus BR upward (see Loci $B'R'$ and $B''R''$, respectively in Fig. 4). For given government spending composition, equilibrium changes to E_1 and E_2, respectively, and economic growth is higher. Moreover, both these changes raise the marginal utility of future consumption, and optimally, the government reduces public consumption shares shifting the Locus OC leftward toward $O'C'$. It follows that equilibrium moves to E_3 and E_4, respectively, thereby increasing economic growth. Therefore, indirectly through increasing optimal productive public service shares by the government resulting in larger capital formation,

[5] The direct negative growth effect in Turnovsky (1996) and the direct positive growth effect in Piras (2001) come both from the congestion in public consumption service, and the direct negative growth effect in Turnovsky (2000) roots in disutility from the reduction in leisure.

a higher intertemporal elasticity of substitution in our model raises economic growth higher than that obtained in existing studies with only a direct effect (e.g., Barro, 1990) and a lower time-preference rate strengthens economic growth than the proposed growth seen from existing literature (e.g., Palivos and Yip, 1995).

Proposition 5 Higher private consumption shares and intertemporal elasticity of substitution and lower time-preference rates all increase optimal productive public service shares in government expenditure resulting in a stronger positive growth effect, as compared with public spending compositions which are exogenous or unresponsive to these factors.

Finally, we must mention that the stronger growth effect under optimal public expenditure composition is not only theoretical, but also quantitative. We have conducted a quantitative calibration exercise. The results indicate that except for the change in β, the induced, indirect growth effect via optimal public spending composition is larger than the conventional direct growth effect, lending supports to the importance of taking public spending composition into consideration when investigating the engines of economic growth.

5. Concluding remarks

This paper studies optimal public spending compositions and their relationships with economic growth and builds a simple, one-sector growth model to investigate these issues. It derives a unique, interior optimal productive public service share of total government budget, and thus a unique interior, optimal public consumption share, which is determined by policy and structural parameters.

This paper finds that economic factors which affect economic growth in conventional wisdom, now yield stronger growth effects from governments' optimal response through its spending share adjustments between productive and consumptive service. These effects emerge because these economic factors change the marginal utility of consumption, relative to the marginal utility of consumption, and therefore, induce governments to redistribute budgets between productive and consumption spending.

Finally, many existing cross-sectional empirical growth studies have investigated the growth effects of productive and consumption public spending. These studies normally use the ratios of public consumption spending to gross domestic products (e.g., Barro and Sala-i-Martin, 1995, Ch. 12), or to total government expenditure (e.g., Devarajan, *et al*., 1996) as a regressor against the long-run growth rate of real *per capita* GDP and estimate and test the effects of public spending upon long-term economic growth. Moreover, observations indicate that East Asian countries have had higher fractions of productive public service in government spending and higher economic growth rates than other countries, among other differences. To the extent that a government optimizes its spending share composition, the shares are determined by the underlying economic structure. Our results suggest that high

productive public service shares in East Asian countries come from their governments' optimal adjustment toward fundamental economic structures. Therefore, a high productive public service share, and thus a low public consumption share, itself, may not be the main underlying reason for explaining cross-country growth differentials. They are the result of the government's optimal choices.

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References

Arrow, K. and Kurz, M. (1970) *Public Investment, The Rate of Return and Optimal Fiscal Policy*, Johns Hopkins University Press, Baltimore, MD.

Aschauer, D. A. (1989) Is public expenditure productive? *Journal of Monetary Economics*, **23,** 177–200.

Baier, S. and Glomm, G. (2001) Long-run growth and welfare effects of public policies with distortionary taxation, *Journal of Economic Dynamics and Control*, **25,** 2007–42.

Barro, R. (1990) Government spending in a simple model of endogenous growth, *Journal of Political Economy*, supplement, Part II, S103–25.

Barro, R. and Sala-i-Martin, X. (1995) *Economic Growth*, McGraw-Hill, Inc., Singapore.

Baxter, M. and King, R. (1993) Fiscal policy in general equilibrium, *American Economic Review*, **83,** 315–34.

Bianconi, M. and Turnovsky, S. (1997) International effects of government expenditure in international economies, *Canadian Journal of Economics*, **30,** 57–84.

Bond, E., Wang, P., and Yip, C. (1996) A general two-sector model of endogenous growth model with physical capital: balanced growth and transitional dynamics, *Journal of Economic Theory*, **68,** 149–73.

Cazzavillan, G. (1996) Public spending, endogenous growth, and endogenous fluctuations, *Journal of Economic Theory*, **71,** 394–415.

CEPD (2001) *Taiwan Statistical Data Book*, Council of Economic Planning and Development, Taipei.

Chang, W.-Y. (1999) Government spending, endogenous labor and capital accumulation, *Journal of Economic Dynamics and Control*, **23,** 1225–42.

Chen, B.-L. (2003), Tax evasion in a model of endogenous growth, *Review of Economic Dynamics*, **6,** 381–403.

Devarajan, S., Swaroop, V., and Zou, H. (1996) The composition of public expenditure and economic growth, *Journal of Monetary Economics*, **37,** 313–44.

Devereux, M. and Wen, J.F. (1998) Political instability, capital taxation and growth, *European Economic Review*, **42,** 1635–52.

Fisher, W. and Turnovsky, S. (1998) Public investment, congestion and private capital accumulation, *Economic Journal*, **108,** 339–413.

Futagami, K., Morita, Y., and Shibata, A. (1993) Dynamic analysis of an endogenous growth model with public capital, *Scandinavian Journal of Economics*, **95,** 607–25.

Glomm, G. and Ravikumar, B. (1994) Public investment in infrastructure in a simple growth model, *Journal of Economic Dynamics and Control*, **18,** 1173–88.

Gramlich, E.M. (1994) Infrastructure investment: a review essay, *Journal of Economic Literature* **32,** 1176–96.

IMF (various years) *Government Finance Statistics Yearbook*, International Monetary Funds, Washington, DC.

Lau, S.-H.P. (1995) Welfare-maximizing vs. growth-maximizing shares of government investment and consumption, *Economics Letters*, **47,** 351–59.

Lee, J. (1992) Optimal size and composition of government spending, *Journal of The Japanese and International Economics*, **6,** 423–39.

Lucas, R.E. Jr. (1990) Supply-side economics: an analytical review, *Oxford Economic Papers*, **42,** 293–316.

Lynde, C. and Richmond, J. (1993) Public capital and long-run costs in UK manufacturing, *Economic Journal*, **103,** 880–93.

Mino, K. (1996) Analysis of a two-sector model of endogenous growth with capital income taxation, *International Economic Review*, **37,** 227–51.

Palivos, T. and Yip, C.K. (1995) Government expenditure financing in an endogenous growth model: a comparison, *Journal of Money, Credit, and Banking*, **27,** 1159–78.

Park, H. and Philippopoulos, A. (2004) Indeterminacy and fiscal policies in a growing economy, *Journal of Economic Dynamics and Control*, **28,** 645–60.

Piras, R. (2001) Government spending composition in an endogenous growth model with congestion, *Metroeconomica*, **52,** 121–36.

Raurich, X. (2003) Government spending, local indeterminacy and tax structure, *Economica*, **70,** 639–53.

Rebelo, S. (1991) Long-run policy analysis and long-run growth, *Journal of Political Economy*, **99,** 492–501.

Shell, K. (1967) A Model of incentive activity and capital accumulation, in K. Shell (ed.) *Essays in The Theory of Optimal Economic Growth,* MIT Press, Cambridge, MA.

Turnovsky, S. (1996) Optimal tax, debt and expenditure policies in a growing economy, *Journal of Public Economics*, **60,** 21–44.

Turnovsky, S.J. (2000) Fiscal policy, elastic labor supply, and endogenous growth, *Journal of Monetary Economics*, **45,** 185–210.

Appendix

Proof of Proposition 1

Proof First, $c(t) = c(0)e^{\phi(s;\tau,A,\beta,\sigma,\rho)t}$ according to (1), and together $\dot{c}/c = \dot{k}/k = \phi$ in BGP and a given $k(0)$, we obtain $g_c(t) = A^{1/\beta}s(1-s)^{1/\beta-1}\tau^{1/\beta}k(0)e^{\phi(s;\tau,A,\beta,\sigma,\rho)t}$. Substituting into $c(t)$ and $k(t)$, the utility is:

$$U = \frac{s(1-s)^{(1/\beta-1)(1-\sigma)}c(0)^{\alpha(1-\sigma)}}{\rho - \phi(s;\tau,A,\beta,\sigma,\rho)(1-\sigma)}. \tag{A1}$$

When the government optimizes s by maximizing (A1), the representative household may respond by adjusting initial consumption instantaneously. Constrained by the household budget constraint, the initial consumption adjusts as follows:

$$\begin{aligned}\frac{\partial c(0)}{\partial s} &= k(0)\left[-\left(\frac{1}{\beta}-1\right)(1-\tau)A^{1/\chi}\tau^{(1/\beta-1)}(1-s)^{(1/\beta-2)}-\frac{\partial \phi}{\partial s}\right] \\ &= k(0)\left(\frac{1}{\beta}-1\right)\frac{\sigma\phi+\rho}{(1-s)}\left(\frac{1}{\sigma}-\frac{1}{\beta}\tau^{(1/\beta-1)(2-1/\beta)}\right).\end{aligned} \tag{A2}$$

Intuitively, when the government devotes a larger share to consumption, both the initial output level and economic growth are reduced. While the former effect reduces consumption initially, the latter effect increases consumption initially. When the intertemporal elasticity of substitution is not large, initial consumption would jump downwards in response to a larger share of public consumption.

Moreover, the initial household budget constraint indicates that:

$$\frac{k(0)}{c(0)} = \frac{1}{(1-\tau)A^{1/\beta}[\tau(1-s)]^{(1/\beta-1)}-\phi} = \frac{\beta}{(\sigma\phi+\rho)\tau^{(1/\beta-1)(2-1/\beta)}-\beta\phi}. \tag{A3}$$

Using (A2) and (A3), we obtain the necessary condition for the government optimization problem:

$$\sigma(1-\alpha)\left(\frac{1}{s}-\frac{1}{\beta}\right) = \left(\frac{1}{\beta}-1\right)(\sigma\phi+\rho)\left(\frac{1}{\sigma\phi+\rho-\phi}+\frac{\left(\sigma\tau^{(1/\beta-1)(2-1/\beta)}-\beta\right)\alpha}{(\sigma\phi+\rho)\tau^{(1/\beta-1)(2-1/\beta)}-\beta\phi}\right). \tag{2}$$

While the left-hand side is the direct marginal utility of current public consumption because of a larger share of public consumption, the right-hand side is the marginal utility of private consumption in the future resulting from lower economic growth because of a smaller share of productive public services. For consistency, it is required that $s<\beta$ so the direct marginal utility be positive.

Finally, if we totally differentiate (2) with respect to φ, τ, β, α, σ and ρ, we obtain the comparative results in Proposition 1.