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Endogenous growth, welfare and budgetary regimes

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Abstract

Within an optimizing endogenous growth model with productive public capital and government debt, we derive and characterize on the balanced growth path a set of welfare-maximizing fiscal rules under different budgetary regimes. It is shown that optimal fiscal policy depends on the specific budgetary stance considered.

JEL classification: E62; H41; H50; O40
Keywords: Endogenous growth; Public capital; Budgetary regimes; Optimal fiscal policy

1. Introduction

One of the novel features of the endogenous growth literature is that it emphasizes the importance of fiscal policy as a determinant of long-run economic growth. In this context, the role of public capital has been investigated at both theoretical and empirical levels. Thus, following the early work by Arrow and Kurz (1970), Futagami et al. (1993) introduce public capital as a pure public good along with private

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capital, but now within an endogenous growth framework. They show how this gives rise to transitional dynamics, which is in contrast to models that highlight the role of productive government *flow* expenditure, where the economy is always on its balanced growth path (see e.g., Barro, 1990; Jones et al., 1993). On the evidence side, Aschauer (1989) reported controversially large estimates for the elasticity of output with respect to public capital for the US (in the range 0.38–0.56), whereas Munnell (1992) reported smaller but still high elasticities that range from 0.15 to 0.2. These figures are, however, in sharp contrast to the findings by Holtz-Eakin (1994), Evans and Karras (1994) among others, who cast doubts on the growth-enhancing effects of public capital.

In an interesting article published recently in this *Journal*, Greiner and Semmler (2000) develop an endogenous growth model with public capital and government debt. Their aim is to investigate the long-run growth effects of public investment policies under different budgetary regimes, which are all versions of the so-called *golden rule of public finance*. This is a budgetary regime that postulates that a government is allowed to run a budget deficit so long as this is used to finance increases in the public capital stock. Greiner and Semmler consider different modifications (based on alternative definitions of the budget deficit) to the "golden rule" and derive the important result that the *growth* effects of an increase in public investment depend on the exact budgetary regime the government operates within. In particular, they demonstrate that less strict budgetary regimes do not necessarily imply higher rates of long-run growth. However, Greiner and Semmler do not attempt to make inferences (analytical or numerical) on the *welfare* aspects of alternative budgetary regimes. This is what we aim to do in this paper. More specifically, we extend the Greiner and Semmler framework to include welfare analysis. We derive, compare and contrast optimal fiscal policy under two different budgetary regimes: the first, being the benchmark case, allows public borrowing through the standard dynamic government budget constraint (DGBC), and the second constrains government policy through the golden rule of public finance (GRPF). We demonstrate analytically that welfare-maximizing fiscal rules differ in the above two cases, and this is in line with the Greiner and Semmler result of growth effects depending on the particular regime under consideration. We show that under certain conditions, the golden rule can be an effective restriction on the composition of government expenditure. We devote the next section to a description of the nature and types of fiscal policy rules in theory and in practice. Section 3 develops the theoretical framework and derives the equilibrium growth rate. Section 4 undertakes the welfare analysis, and the final section concludes.

2. Fiscal rules in theory and practice

A fiscal rule (FR) can be defined as a permanent constraint on policy in the sense that the fiscal authority is expected to be committed to it over a long period of time (e.g., over several business cycles). It is typically defined in terms of an indicator of overall fiscal performance, e.g., a balanced budget condition or a stipulated deficit–

GDP ratio. It is desirable that the rule is well-defined, simple and not too rigidly enforced. A general feature of FRs is that they help to achieve macroeconomic stability and improve the general policy credibility of the government. Without such rules, the economy may be susceptible to election budget cycles, i.e., pre-election overspending followed by post-election fiscal stringency by the party in power. FRs can also reduce negative spillovers when, for instance, there is a monetary union in place, as within the union there is centralized monetary policy but decentralized fiscal policy.

In the real world, FRs can be classified under (a) balanced budget rules, (b) deficit rules, (c) borrowing rules, and (d) debt/reserve rules. [1] A balanced budget rule can be of two types: either requiring current budget balance (as followed in the US and pre-1995 Japan) or cyclically adjusted balance (as in the Netherlands and Switzerland). If such a rule is too rigidly enforced, this may undermine the (short-run) stabilizing role and the tax-smoothing role of fiscal policy. A deficit rule can take the form of the budget deficit being a certain percentage of GDP. For instance, the Stability and Growth Pact, which is at the core of the EMU in Europe, requires member countries to run budget deficits less than 3% of GDP. As regards borrowing rules, a very important FR (provided domestic borrowing is not disallowed, as in Indonesia and Peru) is the GRPF, [2] which is followed in Germany and the UK, whereby borrowing is allowed to finance only public investment (*not* public consumption). An appeal of this rule is that it can channel government expenditure towards projects that are potentially growth-enhancing. Finally, there are FRs in practice that require a certain ratio of debt to GDP or reserves to GDP to be maintained. Perhaps the most important in the former category is the Maastricht criterion of maintaining a debt–GDP ratio of less than 60% for member countries. In the latter category, mention may be made of the targeting of reserves, e.g., a stipulation that social security funds need to be a proportion of annual benefit payments (as in some US states, and Canada). This FR may be invoked for purposes of fiscal sustainability in situations where the economy faces the prospects of sliding into a debt trap.

As is clear from the introduction, our main objective in this paper is to analyse the growth and (more importantly) welfare implications of the GRPF. The reasons for considering this borrowing rule (and not others) is that—apart from its obvious policy relevance—this FR, whereby borrowing is linked directly to public investment, enables us to link budgetary regimes with growth (driven by public capital). From

[1] In the real world, one may find a combination of FRs being pursued by a country at a point in time. The fiscal convergence criteria of the Maastricht Treaty, requiring a deficit rule of 3% alongside a debt rule of 60%, is a case in point.

[2] The origin of the term GRPF is from neoclassical growth theory. Phelps (1961) first referred to the "golden rule" of capital accumulation while describing the optimal growth that gives the maximum sustainable consumption per capita in an economy. The efficient division of output between capital and labor requires that the rate on investment be equated to the time preference of consumers. Budgetary policy in this case should be to just balance the current budget, so as not to affect the overall division between consumption and capital formation. The capital budget in turn should be financed by borrowing, so as to allocate part of savings to investment in the public sector (see also Musgrave and Musgrave, 1989, p. 678). In other words, borrowing for public investment can be justified under the assumption that the return from such investment is sufficient to meet the resulting debt-service obligations.

an empirical standpoint, the golden rule may be interpreted as that the sum of government's surplus and investment expenditure should be non-negative. From Fig. 1, one can easily see that the golden rule has been more often breached than observed in the UK since the mid 1970s, while it has been followed in the last few years. In the international context, it appears from Fig. 2, that a small number of countries failed to observe the rule over an extended period (the 1970s and 1980s). From both figures, it appears that the sum of government's surplus and investment expenditure has been associated with higher GDP growth.

We first contrast the GRPF regime with one where there are no constraints on the *objectives* for borrowing (i.e., the DGBC regime), and then study the impact of a

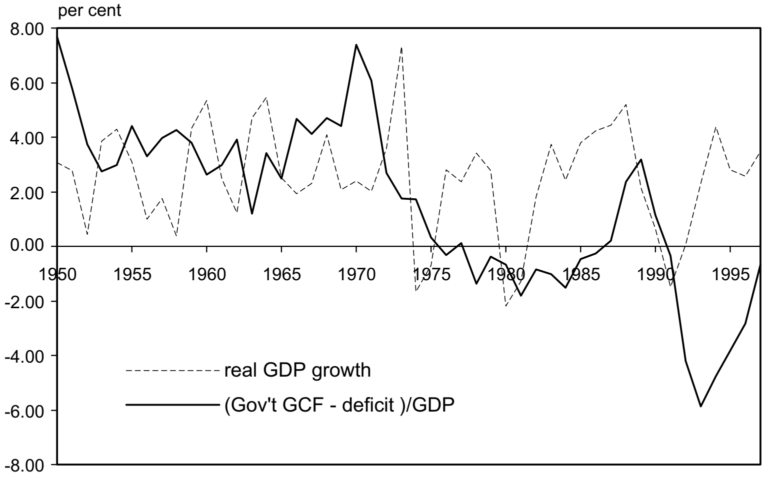

Fig. 1. Growth and the "golden rule" in the UK.

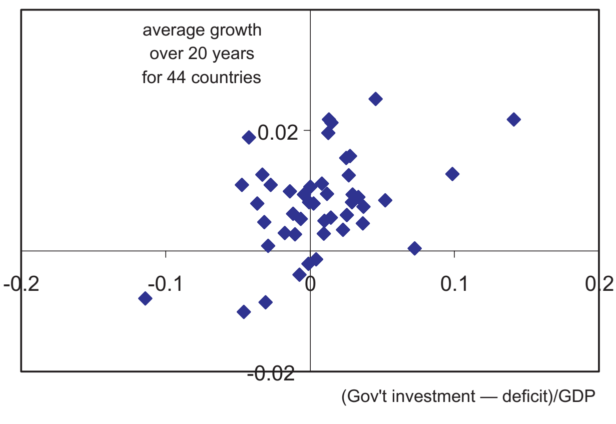

Fig. 2. Growth versus (general govt. GCF – deficit).

more or less strict budgetary stance *within* the GRPF framework. Before we do this, however, we need to spell out the basic model, which is what we do in the next section.

3. The model

The representative infinitely lived agent in the decentralized economy maximizes the discounted sum of utility, as given by

$$U = \int_0^\infty u(C)\mathrm{e}^{-\rho t}\,\mathrm{d}t = \int_0^\infty \frac{C^{1-\sigma}}{1-\sigma}\mathrm{e}^{-\rho t}\,\mathrm{d}t, \tag{1}$$

where C denotes private consumption, ρ is the subjective discount rate and $\sigma(>0)$ is the inverse of the intertemporal elasticity of substitution. The agent's flow budget constraint is given by

$$\dot{K} + \dot{B} = (1-\tau)(Y + rB) - C - T, \tag{2}$$

where K is private capital, B denotes government bonds, r the real rate of return from holding bonds, τ the income tax rate, T the lump-sum taxes, and Y the aggregate output. The rate of depreciation of private capital is assumed to be zero. The production function exhibits constant returns to scale specified in the form:

$$Y = AG_K^{\alpha}K^{1-\alpha}, \quad A > 0, \quad 0 < \alpha < 1, \tag{3}$$

where A is a technological parameter and G_K denotes the public capital stock provided to the household-producer without user charges. The agent chooses C, $\dot{K}$ and $\dot{B}$ to maximize (1) subject to (2) and (3), taking as given all government fiscal variables. This leads to the following first-order conditions:

$$\frac{\partial U}{\partial C}\mathrm{e}^{-\rho t} = \lambda, \tag{4.1}$$

$$\lambda(1-\tau)\frac{\partial Y}{\partial K} = -\dot{\lambda}, \tag{4.2}$$

$$\lambda(1-\tau)r = -\dot{\lambda}, \tag{4.3}$$

where λ is the costate variable associated with (2). In addition, the following transversality condition must hold: $\lim_{t\to\infty}\lambda K\mathrm{e}^{-\rho t} = \lim_{t\to\infty}\lambda B\mathrm{e}^{-\rho t} = 0$. This says that the value of the household's assets must approach 0 as time tends to ∞.

From (4.2) and (4.3), using (3), one can easily obtain:

$$r = \frac{\partial Y}{\partial K} = A(1-\alpha)\left(\frac{G_K}{K}\right)^{\alpha} = (1-\alpha)\frac{Y}{K} = -\frac{\dot{\lambda}}{\lambda(1-\tau)}. \tag{5}$$

By taking logs in (4.1), differentiating with respect to time, using (5) and noting that on the balanced growth path the equilibrium growth rate of the economy, $\varepsilon = \dot{C}/C$, one can derive:

$$\varepsilon = \frac{(1-\tau)r-\rho}{\sigma}. \tag{6}$$

Much of the existing literature has investigated the equivalence between the growth-maximizing ratio of public investment to GDP, $\hat{g}$, and the welfare-maximizing ratio, g^*. Thus in Barro (1990), and Mourmouras and Lee (1999): the Barro framework with finite horizons, the two quantities are equal while, for instance, in Futagami et al. (1993): the Barro framework with public capital instead of flow-expenditure in the production function, and Ghosh and Mourmouras (2002): our two-country version of the Barro model with perfect capital mobility, $g^* < \hat{g}$ holds. Our motivation here is quite different, as our objective is to compare and contrast along the balanced growth path, welfare-maximizing fiscal rules under different budgetary regimes, and this is how we depart from Greiner and Semmler's analysis.

Finally, it is important to note that in our model with steady ongoing growth, for an equilibrium to be sustained, the dynamic adjustment of public capital has to be tied to some index of growth in the economy. A quite standard specification employed in the literature is the following:

$$\dot{G}_K = \eta[\tau(Y + rB) + T], \quad 0 < \eta < 1, \tag{7}$$

where $\dot{G}_K$ is capital spending (i.e., public investment). [3] Eq. (7) states that the government claims a fixed share of taxes for public investment. Our assumed rule is similar to the one in Greiner and Semmler (2000, p. 367). Note also that our results hold even if we assume a rule like that in Devereux and Love (1995, p. 237), where public investment is tied linearly to aggregate output.

In the following section, we derive optimal fiscal policy along the balanced growth path under different budgetary conditions.

4. Welfare-maximizing fiscal rules

In this section we will derive and analyze optimal FRs under the standard dynamic government budget constraint, and the golden rule of public finance. But before doing this, it would be useful to study the nature of the FR under a social planner.

4.1. The social planning optimum

The social planner's task would be to maximize the welfare of agents, where the welfare function is given by (1), subject to the economy-wide resource constraint given below:

$$Y = C + I_P + I_G + G_C, \tag{8}$$

[3] Hence η is a fiscal policy variable. Public capital, like private capital, is assumed not to depreciate.

where I_P ($\equiv \dot{K}$) is private investment, I_G ($\equiv \dot{G}_K$) is public investment, and G_C is government consumption. The planner's choice variables are C, I_P and I_G. The crucial difference between the social planner and a decentralized economy is that the planner takes into account the evolution of K and G_K (and, therefore, in effect chooses the growth rate) while in the latter, the private agents determine the growth rate by choosing how much to invest, taking G_K as given. In the decentralized economy, the private rate of return is less than the social rate of return, and hence, equilibrium growth is inefficient.

From the first-order conditions for the social planner's optimization problem, we easily obtain the stock optimality condition:

$$G_K^{\mathrm{SP}} = \frac{\alpha K}{1-\alpha}, \tag{9}$$

which shows that the planner's optimal ratio of public to private capital is equal to the ratio of the shares of these two inputs in the production function.

4.2. The second-best solution

4.2.1. Fiscal rules under the standard dynamic government budget constraint

This is the case where the government supplements tax revenue by resorting to borrowing from the public through its dynamic budget constraint (DGBC) in order to finance *any* type of spending. In other words:

$$\dot{B} = \dot{G}_K + G_C + rB - \tau(Y + rB) - T. \tag{10}$$

The solvency requirement of the government is that the sum of (i) the present value of future government consumption expenditure, (ii) current government capital expenditure, and (iii) current public debt, should not exceed the present value of future taxes. This is stated in terms of the government's intertemporal government budget constraint as

$$\left[\int_t^{\infty} \mathrm{e}^{-r(s-t)} G_C(s)\,\mathrm{d}s\right] + G_K(t) + B(t) \leqslant \int_t^{\infty} \mathrm{e}^{-r(s-t)} T'(s)\,\mathrm{d}s, \tag{11}$$

where $T'(s)$ refers to *total* (i.e., income plus lump-sum) taxes. The government is not allowed to play a Ponzi game.

The benevolent government's problem, given the DGBC, involves the choice of fiscal instruments that maximize the welfare of the representative agent given by (1) and subject to (2), (10) and (7). Optimization with respect to G_K, T and η, respectively, leads to the following first-order conditions:

$$[\lambda(1-\tau) + \mu_1\eta\tau - \mu_1\tau + \xi\eta\tau]\frac{\partial Y}{\partial G_K} = -\dot{\xi}, \tag{12.1}$$

$$-\lambda + \mu_1\eta - \mu_1 + \xi\eta = 0, \tag{12.2}$$

$$\mu_1[\tau(Y + rB) + T] + \xi[\tau(Y + rB) + T] = 0, \tag{12.3}$$

where μ_1 and ξ are the costate variables associated with (10) and (7), respectively. Manipulating (12.1)–(12.3) and combining the result with (5) we obtain the following *stock* optimality condition:

$$G_K^* = \frac{\alpha K}{(1-\alpha)(1-\tau)}. \tag{13}$$

Condition (13) states that optimal policy consistent with the balanced growth equilibrium requires effectively that the government keeps the public capital stock proportional to the private capital stock. Note also from (13) that a higher τ (which is assumed to be fixed throughout in this paper) increases the public to private capital ratio since there are now more resources for increases in public capital. In addition, in this model where only private capital is taxed (as a matter of fact, as public capital is provided without user charges, private capital is taxed too much) there is now even less private capital accumulation as the after tax return to private investment has gone down. In the extreme case where $\tau \to 1$, i.e., all output is taxed, the ratio $(G_K/K) \to \infty$.

Clearly, the benevolent government's optimization problem is quite different from the social planner's one. The government's optimal choice under the DGBC leads to over-investment in public capital as compared to the planning outcome (for $\tau = 0$, condition (13) coincides with (9)).

4.2.2. Fiscal rules under the golden rule of public finance

This regime postulates that a government is allowed to borrow from the public so long as this is meant to finance productive expenditure. [4] It is well known that the golden rule of public finance (GRPF) is binding for the German government for years now, but it has also recently been adopted by the British government and other European governments. [5] Formally it states that (see also Greiner and Semmler, 2000):

$$\dot{B} = \dot{G}_K - (1-\varphi)[\tau(Y + rB) + T], \quad 0 < \varphi < 1, \tag{14}$$

where φ is the ratio of current spending (including interest payments) to total taxes. [6] Here, as in the DGBC case, the government is not allowed to play a Ponzi game. A

[4] This is Regime *A* in Greiner and Semmler's analysis of the golden rule and the different modifications to it. One can use the argument employed in this section to derive optimal fiscal rules for the alternative budgetary regimes examined in Greiner and Semmler (2000), but this is not our objective here.

[5] In a recent paper, Buiter (2001) casts doubts on the golden rule of public finance as a policy prescription for debt management. He does not look at the growth and welfare effects of the rule, but is rather interested in the implications the rule might have for the intertemporal government budget constraint. He argues that it may not be necessarily prudent for a government to borrow to finance public investment, since willingness to pay and capacity to pay (and service the debt) are not necessarily the same thing.

[6] The same restriction is imposed by Greiner and Semmler (2000, p. 370). Note that the whole point about the golden rule is to link borrowing to public investment, namely, how much the government is allowed to borrow depends on how much it spends on public capital formation. In other words, spending on G_K is the driving force behind public borrowing.

comparison of (10) with (14) reveals that while with the DGBC the government may resort to borrowing in order to finance *any* type of spending, under the GRPF regime borrowing is permissible *only* for productive spending. In that sense, the GRPF regime by putting a ceiling on certain types of spending can be seen as a restriction on the composition of government expenditure. The government maximizes now (1) subject to (2), (7) and (14), and the optimization yields the following first-order conditions:

$$[\lambda(1-\tau)+\mu_2\eta\tau-\mu_2(1-\varphi)\tau+\xi\eta\tau]\frac{\partial Y}{\partial G_K}=-\dot{\xi}, \tag{15.1}$$

$$-\lambda+\mu_2\eta-\mu_2(1-\varphi)+\xi\eta=0, \tag{15.2}$$

$$\mu_2[\tau(Y+rB)+T]+\xi[\tau(Y+rB)+T]=0, \tag{15.3}$$

where μ_2 is the costate variable associated with (14). Manipulation of the above conditions and combining with (5), leads to the following government optimality condition under the golden rule:

$$G_K^{**}=\frac{(1-\varphi)\alpha K}{(1-\alpha)(1-\tau)}. \tag{16}$$

Comparing (16) with (13), it can be observed that the welfare-maximizing ratio of public to private capital in the GRPF regime is lower than in the DGBC regime, the wedge between the two being driven by the parameter φ that features in the golden rule. This implies that the inefficiency associated with over-investment in public capital is *lower* under the golden rule, and this is an important result. [7] In order to understand this, we have to remember that the government under the DGBC is not constrained as regards the type of expenditure that should be financed through public borrowing: it can borrow as much as is required to bridge the gap between total government spending and total taxes. Consequently, borrowing is higher under the DGBC. On the other hand, the requirement for a budget surplus under the golden rule implies less borrowing for any given level of public investment spending. The fact that the government borrows less under the GRPF implies that the return on government bonds is lower, so that the real interest rate (and growth rate) are both lower than under the DGBC. The effects on steady state welfare under the GRPF *vis-á-vis* the DGBC are as follows: (i) a positive substitution effect, since a lower interest rate (i.e., a lower return to private investment) moves resources to private consumption, (ii) a negative wealth effect, since a lower interest rate implies lower interest income on debt, and (iii) a negative effect from a lower growth rate.

Focusing on Eq. (16), it is important also to note that *within* the GRPF regime, a higher φ (representing a *less* strict budgetary stance) implies a *lower* optimal ratio of public to private capital. To understand the intuition behind this result, it ought to be noted that borrowing is earmarked to finance only public investment (not public

[7] One can easily see from (16) that for $\varphi=\tau$, the ratio (G_K/K) is reduced to the social planner's optimum.

consumption) under the GRPF. Given this scenario, a higher φ implies higher current spending (i.e., in general, higher G_C) which crowds out productive investment by more than would be the case with a lower φ. This leads to a lower interest rate and growth rate. The response of the government to the higher G_C will be to reduce G_K for a given amount of borrowing—see Eq. (14) characterizing the government budget constraint under the GRPF—consequently, public investment ($\dot{G}_K$) will be less in equilibrium, and therefore, borrowing ($\dot{B}$) will be less.

In order to study the effects on steady state welfare of a more or less strict budgetary stance within the GRPF regime, it would be useful to derive an expression for (indirect) utility—based on Eq. (1)—under this regime, which is given as follows:

$$W = \frac{1}{1-\sigma} \cdot \frac{C_0^{1-\sigma}}{\rho - (1-\sigma)\varepsilon}. \tag{17}$$

From the utility expression given above, it is clear that—with α, ρ, σ, and also τ being parametrically given—φ affects W along the balanced growth path through the growth rate, ϵ, and initial consumption, C_0.

We have noted already that a higher φ results in lower G_K/K (Eq. (16)) and this will result in lower ϵ (via Eqs. (5) and (6)). Clearly, from Eq. (17), a smaller value of ϵ will result in a smaller value of W. The effect of a higher φ on C_0 will also be negative, providing higher G_C crowds out private consumption by more. Since government consumption under the GRPF has to be financed (necessarily) through taxes, so higher φ will be associated with higher taxes. In this model, we have lump-sum as well as income taxes, but the income tax rate is parametrically given. Therefore, lump-sum taxes will have to be higher for higher φ. This is exactly what happens, as our simulations demonstrate. [8] So the effect on C_0 is, indeed, negative. Thus, higher φ results in lower W through this route as well. Overall, our results show that within the GRPF regime, a less strict budgetary stance, operating through the different channels, leads to a lowering of welfare along the balanced growth path.

Finally, we have done a sensitivity analysis, whereby we study the effects of changes in the parameters α, ρ and σ on welfare, corresponding to particular values of φ. Figs. 3–5, which have been constructed on the basis of our numerical results, clearly show that a larger value of φ (i.e., a less strict budgetary stance) results in a smaller value of W (i.e., lower welfare).

5. Conclusions

Within an optimizing endogenous growth model with productive public capital and government debt, we derived and characterized on the balanced growth path a set of welfare-maximizing fiscal rules under two alternative budgetary regimes: one that allows public borrowing through the standard dynamic government budget constraint, and another, known as the golden rule of public finance, that allows a

[8] Our simulation results are available upon request.

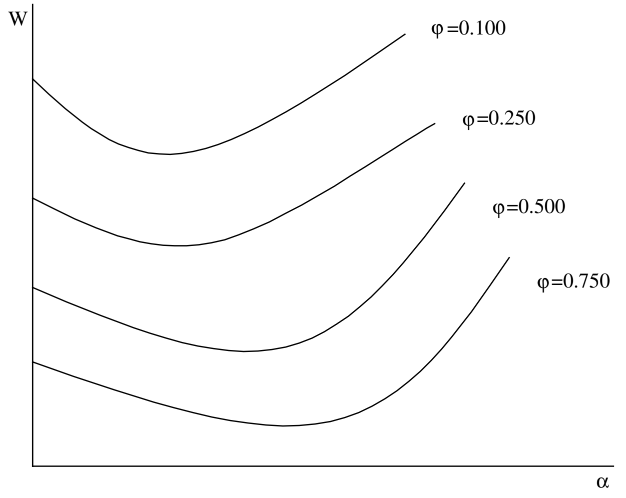

Fig. 3. Plot of W against α for different values of φ. Sensitivity analysis: effects of changes in α on welfare (W), corresponding to different values of φ.

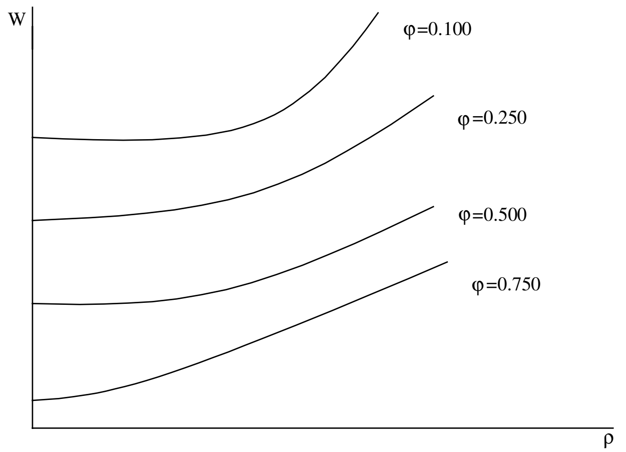

Fig. 4. Plot of W against ρ for different values of φ. Sensitivity analysis: effects of changes in ρ on welfare (W), corresponding to different values of φ.

government to run a deficit so long as this is meant to finance public investment. We demonstrated analytically that optimal fiscal policy differs in the two budgetary regimes. In particular, it was shown that under the golden rule, the inefficiency associated with over-investment in public capital may, indeed, be reduced. We also showed that within the GRPF framework, a less strict budgetary stance leads to a smaller ratio of public to private capital and lower borrowing in equilibrium, and may actually result in lower steady state welfare.

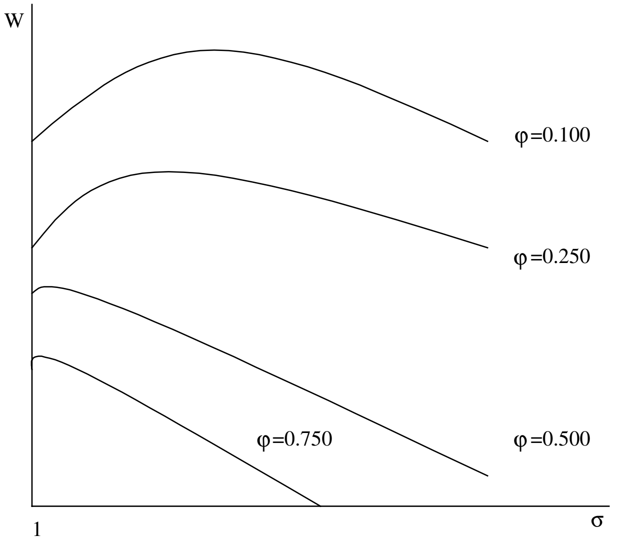

Fig. 5. Plot of W against σ for different values of φ. Sensitivity analysis: effects of changes in σ on welfare (W), corresponding to different values of φ.

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