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THE IMPACT OF SIMPLE FISCAL RULES IN GROWTH MODELS WITH PUBLIC GOODS AND CONGESTION*

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In this paper we examine the implication of a simple class of fiscal rules for long-run economic growth and welfare. The Golden Rule of Public Finance that we examine is motivated by institutional arrangements in countries such as Germany and the UK. We find that rules that seek to limit government borrowing to productive investment spending have a clear justification in terms of growth and welfare when government-provided goods are otherwise excessively provided. Even in the case where it is private consumption that is excessive, the Golden Rule of Public Finance is likely to be good from a growth perspective, but the welfare effects are more ambiguous.

1 Introduction

More and more countries are adopting fiscal rules. They may become an important feature of the macroeconomic landscape in the same way as central bank independence has emerged as a dominant institutional arrangement for monetary policy across an increasing number of countries. Some argue that fiscal rules are a complement to monetary rules—both ultimately aimed at price stability. However, fiscal rules may also have long-term growth implications. And, in fact, the endogenous growth literature has indicated that there are indeed long-run growth implications of fiscal policies. But what actually are the growth and welfare implications of such rules, and what are the underlying distortions that they seek to address? In this paper we take a preliminary look at these issues.

1.1 Related Literature

In this paper we focus on a simple class of fiscal rules, among which is the Golden Rule of Public Finance (GRPF), which is motivated by actual 'rules'

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adopted in several countries, notably Germany and the UK. Under the GRPF, government borrowing is constrained for investment purposes only. In other words, the government cannot borrow to boost its non-durable consumption. Ultimately, fiscal rules of the sort analysed here have two effects. First, they may constrain the overall size of the public sector as measured by the sum of government spending. In our set-up the government supplies a non-durable, non-rival and non-excludable consumption good, and a rival but non-excludable investment good. Second, by changing the social cost of a unit of public investment the GRPF, *ceteris paribus*, reduces the amount of the investment good necessarily below the optimal level. However, the implications for growth and welfare of our class of fiscal rules are not clear-cut. For example, if government spending on the non-durable, non-rival and non-excludable consumption good is sufficiently high, the imposition of the GRPF may result in sufficiently low tax rates such as to compensate for the lower level of the non-excludable investment good (an input in the production technology). However, the lower level of the government investment good will also have a direct effect on growth via the interest rate. Tracing out how these complicated general equilibrium effects work themselves out in this and the other cases that we analyse is a main contribution of this paper.

On the issue of fiscal rules, Greiner and Semmler (2000) is an important paper, which investigates long-run growth performances under alternative budgetary regimes (in particular, the GRPF), in an endogenous growth model with public capital and public debt. They show that the growth effects of an increase in public investment depend on the exact budgetary regime within which the government operates. In particular, they demonstrate that less strict budgetary regimes do not necessarily imply higher rates of long-run growth. These authors do not, however, analyse the welfare implications of such budgetary rules. Ghosh and Mourmouras (2004b), who extend the Greiner and Semmler framework to include welfare analysis, have studied precisely this aspect. They demonstrate analytically that welfare-maximizing fiscal rules differ depending on whether or not government borrowing is earmarked to finance only productive public spending, and this is in line with the Greiner and Semmler result of growth effects depending on which particular regime is in place.

However, these papers set to one side two important issues. First, how do these simple rules affect growth and welfare when congestion effects are present? Second, in the face of what distortions does a fiscal rule (like the GRPF) make sense? Turning to the first question, we first need to establish why it is important to study congestion-type effects in the first place, and what the prominent effects of fiscal policies in such settings are. As argued by Barro and Sala-i-Martin (1995), virtually all public services—including perhaps national defence—are characterized by some degree of congestion. The classic paper by Barro and Sala-i-Martin (1992) demonstrates that income taxation operates as a user fee for rival but non-excludable public goods and prevents the growth rate from being too high, something that lump-sum taxation cannot achieve. Turnovsky (1997) captures congestion effects in a model with public capital, and characterizes the transitional dynamics under alternative fiscal policies. He also derives a time-varying income tax that could enable the decentralized economy to replicate both the short- and long-run behaviour achievable under a social planner. Fisher and Turnovsky (1998) show how the effect of government investment on private capital formation involves a trade-off between the degree of substitution between private and public capital in production and the degree of congestion. Here, neither lump-sum nor distortionary tax financing of public investment is optimal.

Turning to the second question, we are not aware of any studies that look at whether simple fiscal rules help ameliorate the welfare implications of the sorts of issues we have just mentioned. The present paper can be seen, in part, as a preliminary attempt to address this omission.

As is clear from above, an important aspect of endogenous growth theory over the years has been the study of how fiscal variables, on both the expenditure and revenue sides, affect the long-run growth rate of an economy. On the expenditure side, Barro (1990) shows how the presence of productive public services, as an input in the production function, can affect steady-state growth. This seminal paper by Barro considers the flow of public services rather than the stock of public capital. Futagami *et al.* (1993) consider the latter, and demonstrate the existence of a unique steady growth equilibrium with private and public capital. They also analyse the transitional dynamics of their model. Departing from the balanced budget set-up of the two papers cited above, Bruce and Turnovsky (1999), considering an array of fiscal instruments, identify the conditions under which a tax cut (by itself, or with accompanying expenditure cuts) can improve the long-run government budget balance. They do not, however, focus on the impact of aggregative fiscal rules, despite the growing prominence of such rules in policy debates. This is what we aim to do in this paper, within a Bruce and Turnovsky (1999) type framework.

Another of our objectives is to construct model economies in which the decentralized equilibria reflect a number of externalities. We then identify the circumstances in which the GRPF can improve on the decentralized outcome.

The externalities referred to above reflect situations where private and government consumption are, in turn, excessive relative to the social optimum. For simplicity, we build these distortions directly into our baseline model via our assumptions on household preferences. We view these distortions as proxies for richer political-economy-type features. For instance, as Drazen (2000, p. 380) notes, '. . . there is no presumption about whether decision making by majority voting leads to a level of public good provision either systematically above or below the [social] optimum level'.[1] In practice, the arguments are made both ways. For instance, some have argued that market economies have a built-in dynamic that constrains (some) public good provision to fall increasingly behind private consumption to the detriment of economic welfare; this is in part what lies behind Galbraith's quip concerning 'private opulence and public squalor'.[2] On the other hand, some, like Buchanan, have argued that the public sector in market economies, under the influence of pressure group activity, has a tendency to grow too big.[3] Ultimately, governments may be tempted to supply goods that the market could otherwise supply, or government activity may result in the crowding out of productive private investment. More formally, there has been much empirical and theoretical work aimed at understanding the size and scope of government; see, for instance, Alesina and Perotti (1995) and Drazen (2000).

1.2 Outline of the Paper

In the next section we set out a baseline model with conventional assumptions as regards the preferences of agents, and with congestion effects in the production technology, as in Barro and Sala-i-Martin (1992). We then examine the equilibrium paths of the model's key variables and calculate the present value of utility under a number of scenarios. First, we analyse the decentralized equilibrium when the purpose of government borrowing is unconstrained. Second, we examine what happens when the fiscal authorities are constrained to borrow only for productive purposes (i.e. to boost the level of the non-excludable investment good). Finally, we compare these outcomes to the social optimum.

In Section 3 we analyse the situation when the decentralized equilibrium is characterized by excessive private consumption. Again we compare this outcome with that when the government follows a fiscal rule, and under the social optimum. In Section 4 we examine an alternative scenario when the decentralized equilibrium is characterized by excessive government supply of the non-durable, non-rival and non-excludable consumption good. Section 5 sums up our key results and concludes.

2 Basic Model with Congested Technology

We start off with a conventional preference and production set-up in order to establish some baseline results. There are a large number of individuals in this

[1]See also the discussion in Atkinson and Stiglitz (1980).

[2]See, for example, *The Affluent Society* (Galbraith, 1987) or *Economics and the Public Purpose* (Galbraith, 1974) for an articulation of this type of concern. That said, to our knowledge, Galbraith has never recommended fiscal rules of the sort analysed in this paper.

[3]See Buchanan (1972), who expresses concern at the constant pressure faced by governments from the electorate to reduce taxes and, at the same time, to expand both the range and extent of the various public services.

economy, say n. The size of the population, for simplicity, is fixed for all time at this number. The present value of utility, V, and the flow utility, U, for the ith individual are given by

$$V = \int_0^\infty U(c, G_c)\mathrm{e}^{-\rho t}\mathrm{d}t \qquad \rho > 0$$
$$U(c, G_c) = \frac{(c^{1-\eta}G_c^{\eta})^{1-\sigma}}{1-\sigma} \qquad \sigma > 0, 0 < \eta < 1 \tag{1}$$

Here c denotes per capita consumption, G_c denotes consumption of the government-supplied public good, and ρ is the rate of time preference. Generally we adopt the convention that $X = nx$, where lower case letters denote per capita values while upper case denotes economy-wide aggregates. The budget constraint for this individual is

$$\dot{k} + \dot{b} = (1-\tau)(y + rb) - c \tag{2}$$

A dot above a variable denotes a time derivative. k denotes the capital stock, b denotes government bonds, τ is the tax rate, y is output and r is the interest rate. The production technology is described by

$$y = Ak(G_{\mathrm{I}}/K)^{\beta} \qquad \beta > 0 \tag{3}$$

The production function captures the sense in which there is congestion in public services, as in Barro and Sala-i-Martin (1992). G_{I} is aggregate government expenditure on the investment goods. Hence, since it is G_{I}/K that appears in the production function, the public investment good is rival but not excludable; we cannot preserve a portion of G_{I} for our own use (hence non-excludable), and the higher our capital stock is relative to another producer, the smaller are the facilities available for production to that producer (hence rival). As a consequence of this, we may think of G_{I} as both the per capita level of government expenditure on the investment good, and the aggregate level of this expenditure. We may also consider G_c, which is non-rival *and* non-excludable, to be a per capita and aggregate quantity.

2.1 *The Decentralized Outcome*

Throughout the paper we shall assume that initial debt is positive, $nb(0) > 0$. We assume that the usual transversality conditions with respect to bonds and capital hold. The optimality conditions of the representative household maximizing (1) subject to (2) and (3) include

$$(1-\eta)c^{(1-\eta)(1-\sigma)-1}G_c^{\eta(1-\sigma)}\mathrm{e}^{-\rho t} = \lambda \tag{4}$$

$$\dot{\lambda} = -\lambda(1-\tau)\frac{\partial y}{\partial k} = -\lambda(1-\tau)r \tag{5}$$

In an appendix (available on request) we set out the optimization problem in detail and indicate why λ is related to both the dynamic behaviour of bonds and capital. The decentralized interest rate is related to the evolution of the costate variable as follows:

$$r = \frac{\partial y}{\partial k} = -\frac{\dot{\lambda}}{\lambda(1-\tau)} \tag{6}$$

where we have that

$$\frac{\partial y}{\partial k} = A(G_{\mathrm{I}}/K)^{\beta} \tag{7}$$

In a symmetric equilibrium we then have that

$$r = An^{-\beta}k^{-\beta}G_{\mathrm{I}}^{\beta} \tag{8}$$

Balanced growth is derived by taking logs of equation (4) and differentiating with respect to time:

$$\frac{\dot{\lambda}}{\lambda} = [(1-\eta)(1-\sigma)-1]\frac{\dot{c}}{c} + \eta(1-\sigma)\frac{\dot{G}_c}{G_c} - \rho \tag{9}$$

Along the balanced growth path, $\phi \equiv \dot{c}/c = \dot{G}_c/G_c$. Hence, from (5),

$$\begin{aligned}\phi &= \frac{(1-\tau)r-\rho}{\sigma} \\ &= \frac{(1-\tau)An^{-\beta}k^{-\beta}G_{\mathrm{I}}^{\beta}-\rho}{\sigma}\end{aligned} \tag{10}$$

To make progress on this expression, we shall need to solve for the equilibrium behaviour of G_{I}. We do this under various assumptions about the constraints that impinge on the government's behaviour. The first regime we analyse is one where the government chooses the fiscal variables to maximize the utility of a representative agent, respecting the agent's and its own flow budget constraints. We label this the DGBC regime (standing for the dynamic government budget constraint). The second regime we analyse is one where the GRPF is in place. This rule in effect places an additional restriction on the government such as to constrain the level of G_c at some arbitrary level. Finally we compare the outcomes under these decentralized equilibria with the outcome under the social optimum and enquire whether the GRPF is welfare enhancing or not.

2.1.1 The Benevolent Government's Problem under the DGBC. We note that the flow budget constraint of the government is

$$\dot{B} = rB + G_c + G_{\mathrm{I}} - \tau(Y + rB) \tag{11}$$

This expression, in per capita terms, enters the maximization of the benevolent government. The Hamiltonian may then be written as

$$H = (1-\sigma)^{-1}(c^{1-\eta}G_c^{\eta})^{1-\sigma}\mathrm{e}^{-\rho t} + \lambda[(1-\tau)(y+rb)-c] + \mu[rb + G_{\mathrm{I}} + G_c - \tau(y+rb)]$$

where the two side constraints may be combined to show that, when aggregated up, $Y = \dot{K} + G_c + G_{\mathrm{I}} + C$, as we require of any fiscal plan. As we show below at an optimum $\lambda = -\mu$, so that the government's plan does indeed respect the economy-wide budget constraint. The first-order conditions with respect to the government's choice variables, G_c, G_{I} and τ, respectively, yield

$$\eta c^{(1-\eta)(1-\sigma)}G_c^{\eta(1-\sigma)-1}\mathrm{e}^{-\rho t} = -\mu \tag{12}$$

$$\mu + \lambda(1-\tau)\frac{\partial y}{\partial G_{\mathrm{I}}} = \mu\tau\frac{\partial y}{\partial G_{\mathrm{I}}} \tag{13}$$

$$-\lambda(y+rb) = \mu(y+rb) \tag{14}$$

Since $\lambda = -\mu$ implies $\partial y/\partial G_{\mathrm{I}} = 1$, we find that

$$G_{\mathrm{I}} = \beta Y \tag{15}$$

$$G_c = \frac{\eta}{1-\eta}C \tag{16}$$

Equation (12) can be manipulated as we did above using (4) to yield an expression for the balanced growth path of the economy. Since this remains a decentralized equilibrium we continue to find

$$\phi = \frac{(1-\tau)Ak^{-\beta}\beta^{\beta}y^{\beta} - \rho}{\sigma} \tag{17}$$

where we have used (15) to substitute out for G_{I}.

2.1.2 The Benevolent Government's Problem under the GRPF. Under what we here call the GRPF, we constrain the government such that it can only borrow for productive spending purposes, i.e. to boost the supply of G_{I}. The quantity $G_c + rB$ must then be met out of period taxation. If we assume that $G_c + rB$ does not exhaust all the period tax receipts then it follows that

$$G_{\mathrm{I}} = (1-\theta)\tau(Y + rB) + \dot{B} \tag{18}$$

where θ is the ratio of the government's current expenditure (including interest payments on debt) to its total tax revenues, and $0 < \theta < 1$. Here, our formulation of the GRPF follows Ghosh and Mourmouras (2004b), which in turn follows the formulation in Greiner and Semmler (2000). It is motivated directly by the institutional arrangements in Germany and the UK. We note that we may not now regard G_c as a choice variable. The equilibrium value of bond holdings (as captured by the equilibrium value of the costate variable) and the equilibrium value of r (as determined by the production technology) combine with θ (which is parametrically given) and mean that G_c is effectively determined by residual.[4] In this case, we find that $\lambda = -\nu(1-\theta)$. It follows that

$$G_{\mathrm{I}} = \beta(1-\theta)Y \tag{19}$$

and

$$G_c = \theta\tau(Y + rB) - rB \tag{20}$$

Along the balanced growth path, as before $\phi \equiv \dot{c}/c = \dot{G}_c/G_c$, we have that

$$\phi = \frac{(1-\tau)(1-\theta)^{\beta} A k^{-\beta} \beta^{\beta} y^{\beta} - \rho}{\sigma} \tag{21}$$

The key distortion associated with the GRPF is that the social cost of a unit of public investment is higher under the GRPF as opposed to the DGBC (compare (19) with (15)).[5] Under the GRPF a higher θ is associated with a higher marginal social cost as it implies higher (non-productive) current spending. When $\theta = 0$, the social cost is the lowest (= 1) because all spending by the government is for productive purposes. Next, comparing the GRPF (with $\theta = 0$, where all spending is for productive purposes) with the balanced budget case of Barro (1990) with only productive spending, the social cost is 1 for both, as should intuitively be the case. In terms of social cost, the 'problem' with the GRPF is that (unless $\theta = 0$) the government is earmarking some expenditure for non-productive purposes at the outset, whereas under the DGBC it is not. We note, however, that this does not mean that G_c cannot be higher under the DGBC, *ex post*. This will be apparent in the simulations that we report below. This also does not imply that the optimal value of θ is zero, since G_c enters utility directly and so the marginal utility of G_c rises as G_c falls. It is also intuitively clear that $\theta = 1$ is also not optimal as that implies a zero level of output. Consequently, optimal θ lies in the open unit interval.

[4]The Hamiltonian for this problem is written as

$$H' = (1-\sigma)^{-1}(c^{1-\eta}G_c^{\eta})^{1-\sigma}\mathrm{e}^{-\rho t} + \lambda[(1-\tau)(y + rb) - c] + \nu[G_{\mathrm{I}} - (1-\theta)\tau(y + rb)]$$

[5]As we have considered policy choices facing a benevolent government when the GRPF with a non-zero θ is in place, we do not substitute (20) into the utility function in deriving the first-order conditions. Doing so would change the nature of the government's optimization problem, yielding the result that if the government over-provides (under-provides) G_{I}, then it under-provides (over-provides) G_c. In that scenario, the optimal provision of G_{I} and G_c implies (15) and (16) respectively, which hold when $\theta = 0$; i.e. $\theta \neq 0$ constitutes a suboptimal policy.

2.2 The Social Optimum

We now compare the above outturns with the result of a social planning optimum.[6] The optimality conditions imply that

$$G_c = \frac{\eta}{1-\eta} C \tag{22}$$

and

$$G_{\mathrm{I}} = \beta Y \tag{23}$$

The interest rate is given by

$$r = (1-\beta) A \beta^{\beta} y^{\beta} k^{-\beta}$$

and, in turn, the balanced growth rate is

$$\phi_{\mathrm{SO}} = \frac{(1-\beta) A k^{-\beta} \beta^{\beta} y^{\beta} - \rho}{\sigma} \tag{24}$$

We compare balanced growth under the social optimum (ϕ_{SO}) with the outturn under the DGBC (ϕ_{DGBC}) and the GRPF (ϕ_{GRPF}):

$$\phi_{\mathrm{DGBC}} = \frac{(1-\tau) A k^{-\beta} \beta^{\beta} y^{\beta} - \rho}{\sigma} \tag{25}$$

$$\phi_{\mathrm{GRPF}} = \frac{(1-\tau') A k^{-\beta} \beta^{\beta} (1-\theta)^{\beta} y'^{\beta} - \rho}{\sigma} \tag{26}$$

We find that growth under the social planner is higher than the other regimes so long as the following conditions obtain. If the capital share is larger than the tax distortion

$$1-\beta > 1-\tau \tag{27}$$

then we find that $\phi_{\mathrm{SO}} > \phi_{\mathrm{DGBC}}$. Furthermore, if it is also the case that

$$1-\theta > \left(\frac{1-\tau}{1-\tau'}\right)^{1/\beta} \frac{y}{y'} \tag{28}$$

then we find that

$$\phi_{\mathrm{SO}} > \phi_{\mathrm{GRPF}} > \phi_{\mathrm{DGBC}} \tag{29}$$

This ordering of the growth rates is plausible but by no means inevitable. The GRPF, in so far as it constrains public consumption, ought to reduce taxes which are the only source of financing such spending. Besides, the fact that

[6]The Hamiltonian for this problem is

$$H^{p} = (1-\sigma)^{-1} (C^{1-\eta} G_c^{\eta})^{1-\sigma} \mathrm{e}^{-\rho t} + \lambda_p (Y - C - G_c - G_{\mathrm{I}})$$

TABLE 1
CONGESTED PRODUCTION ONLY

	DGBC	*GRPF*	*Social optimum*
Output	2.873	2.354	2.873
Private consumption	1.172	1.237	1.022
Government consumption	0.293	0.042	0.256
Government investment	0.718	0.324	0.718
Real interest rate	0.144	0.118	0.108
Tax rate	0.380	0.192	
Growth rate	0.035	0.038	0.044
Value function	–20.659	–27.603	–20.215

Note: Parameter values/initializations: $A = 0.33$, $\beta = 0.25$, $\sigma = 2$, $\eta = 0.2$, $\rho = 0.02$, $\theta = 0.45$, $K(0) = 20$ and $B(0) = 1.5$.

the public investment to output ratio is smaller under the GRPF should also have an effect in lowering taxes. Indeed, numerical simulations of the model suggest that the ordering in (29) is the likely ordering, as we shall see below.

2.3 *Simulations and Discussion of Results*

Table 1 displays the results of some simulations of the above model economies (Appendix A explains how we constructed these numerical solutions).[7] As compared with the case of the DGBC and the social optimum, the level of productive investment is somewhat lower under the GRPF, which implies for a given capital stock a somewhat lower level of period output. This lower level of G_I is consistent with a higher level of private consumption, *ceteris paribus*, but can imply a sharp contraction in G_c, as in Table 1, suggesting offsetting implications for utility. The smaller size of the public sector under the GRPF may imply lower period taxation, and higher equilibrium growth. But a lower level of G_I implies a lower real interest rate. Table 1 displays, for a particular parameterization, how these various factors play out.

Note that even though the level of output is the same under the social optimum and the DGBC (factor inputs are the same—capital is inherited from the last period while the optimal level of G_I is the same in both set-ups), the rate of interest differs. Under the DGBC, people do not take into account the fact that their individual production decisions create congestion effects, which explains the higher real interest rate, while under the social planner, internalization of the congestion effect causes a lower interest rate but a higher long-run growth rate. (Under the DGBC, distortionary taxation scales down

[7]We carried out extensive robustness exercises of all of our numerical simulations and an appendix is available on request. These confirmed the basic results that we discuss now and in the rest of the paper. Briefly, we allowed A to vary between 0.1 and 0.6, β to vary between 0.1 and 0.4, σ to vary between 0.5 and 5, η to vary between 0.1 and 0.4, ρ to vary between 0.005 and 0.1, $K(0)$ between 5 and 50 and $B(0)$ between 0.5 and 15. In addition, θ was varied between 0.25 and 0.65.

the growth effect considerably, as the numbers demonstrate.) Private consumption is consequently lower under the SO, but still the present discounted value of utility is higher under the planner because of the higher growth rate.

In this set-up, the GRPF can actually deliver a higher growth rate (which is closer to the social optimum) than under the DGBC, so long as the ratio of current spending to taxes (θ) is not too high.[8] Given our other parameters/initial values, even a value of θ close to 0.60 can result in a growth rate that is higher than under the DGBC. This is because of the much lower government consumption[9] and tax rate implied by the GRPF. Clearly, the value of θ has a bearing on the present discounted value of utility through its impact on C and G_c. A higher value of θ will tend to increase utility directly by raising, *ceteris paribus*, G_c (although it also crowds out private consumption). A higher value of θ also reduces output below what it would otherwise have been, by reducing G_I, and it also acts directly to lower the growth rate, by lowering the rate of interest. However, since $G_c = \theta\tau(Y + rB) - rB$, this implies a somewhat lower level of taxes, and growth ends up higher under the GRPF than under the DGBC.

While the numbers presented in the table show that welfare is higher under the DGBC than under the GRPF, it is theoretically possible to have the opposite for certain values of θ. One thing that emerges quite clearly from the numbers for the model with congestion in production is that, under the GRPF, for a large range of plausible values for θ, the real interest rate and growth rate are closer to the social optimum than under the DGBC.

3 A Simple Model of Excessive Private Consumption

As we indicated in Section 1, the public finance literature suggests majority voting can lead to a level of public good provision either systematically above or below the social optimum level. In practice, this means the sum of marginal utilities will differ from that implied under the 'Samuelson rule'. In our set-up we model this as a deviation in the marginal rate of substitution from what it would be under the social optimum. For a given level of G_c/c, we have that

$$\mathrm{MRS_c} < \mathrm{MRS_{SO}}$$

where MRS_c denotes the marginal rate of substitution in the excess private consumption case, and $\mathrm{MRS_{SO}}$ denotes the marginal rate of substitution in the social optimum. See Fig. B1 in Appendix B for a graphical representation of these cases. We therefore replace (1) with

[8]We note that $\theta = 0.45$ is consistent with the deficit: GDP ratio being in the region of 2%–2.5%. Ghosh and Mourmouras (2004a) find that this is approximately the optimal ratio of current non-productive spending (including interest payments) to tax revenue in a similar set-up to that here for an average tax rate of around 0.3.

[9]Note that the link between C and G_c as given by equation (16) no longer exists, and G_c in general rises with θ.

$$U = \frac{[c^{1-\eta+\gamma} g(G_c/C) G_c^{\eta-\gamma}]^{1-\sigma}}{1-\sigma} \tag{30}$$

where

$$g(G_c/C) \equiv (G_c/C)^{\gamma}$$

It follows then that

$$\mathrm{MRS_{SO}} = -\frac{1-\eta}{\eta}\frac{G_c}{c}$$

$$\mathrm{MRS}_c = -\frac{1-\eta+\gamma}{\eta-\gamma}\frac{G_c}{c}$$

This utility function will generate a decentralized equilibrium, under a benevolent government, where *private* consumption is excessive.[10] In such an environment we might not expect to see beneficial results from fiscal rules where the ultimate aim is to constrain the government in some way. One may think this since it will be private behaviour, not the government's behaviour, that is different from the outcome under the social optimum. However, that intuition may not go through. We are in a second-best world, and as the previous simulation results demonstrated, the GRPF may act to reduce private consumption.

The decentralized equilibrium under a benevolent government operating with the DGBC is characterized by the following pair of relations:[11]

$$G_{\mathrm{I}} = \beta Y \tag{31}$$

$$G_c = \frac{\eta-\gamma}{1-\eta+\gamma} C \tag{32}$$

With a government operating within the GRPF, the following pair of equilibrium relations obtain:

$$G_{\mathrm{I}} = \beta(1-\theta)Y' \tag{33}$$

and

$$G_c = \theta\tau(Y' + rB) - rB \tag{34}$$

The optimality conditions under the social planner remain unchanged from Section 2.2, as expected.

[10]See Galbraith (1987, p. 192) for a somewhat colourful exposition of these types of concerns.
[11]The full derivation of these results are included in an appendix available from the authors upon request.

Table 2
Congested Production and Excess Private Consumption
($\gamma = 0.1$)

	DGBC	*GRPF*
Output	2.873	2.354
Private consumption	1.252	1.237
Government consumption	0.139	0.042
Government investment	0.718	0.324
Real interest rate	0.144	0.118
Tax rate	0.329	0.192
Growth rate	0.038	0.038
Value function	–21.299	–27.603

Note: See Table 1 for additional parameter settings.

Balanced growth is derived in the usual way. We compare the balanced growth rates under the social optimum, the GRPF and the DGBC, as we did above.

The same basic considerations seem to apply here, as before in Section 2. The important, and perhaps surprising, thing to note here is that although the GRPF appears to be addressing the 'wrong' problem (it is constraining G_c when it is c that is excessive), it nevertheless has the ability to deliver a higher growth rate, as before, because it makes possible a lower level of distortionary taxes. However, this higher growth rate need not be informative as to the welfare rankings of these fiscal regimes, as the simulation results in the next section make clear.

3.1 *Simulations and Discussion of Results*

Comparing the numbers in Table 2 with those in Table 1 for the case where the DGBC is in place, it is clear that private consumption is higher and this is quite intuitive, as in this case agents do not take into account the fact that if they increase their individual consumption (c) out of the public good (G_c), then this increases the overall C/G_c ratio for the economy. So C is higher and G_c lower than the benchmark case of Table 1. The nature of the congestion on the production side remains the same as in Table 1, which gives rise to identical real rates of interest in the two cases. Given this (together with identical Y and G_I and lower G_c), the tax rate has to be lower in Table 2, which implies that the growth rate is higher. The values with the GRPF in place will, of course, remain unchanged from Table 1, but it is clear from the numbers that, if there is congestion in consumption as well as in production, then this gives rise to values of C, G_c, τ and ϕ that are closer to the GRPF numbers than where there is congestion in production alone. The present discounted value of utility could go either way. Where the DGBC is in place, C is higher and

G_c lower in Table 2 than in Table 1. This means that the values of U and ϕ are closer to those attained under the GRPF.[12]

4 A Simple Model of Excessive Public Consumption

The utility function of the previous section was intended to capture what many might argue is a risk in modern economies: private agents not internalizing all the implications of their consumption plans. One important upshot of this was that, relative to the social optimum, we encountered excessive private consumption.

However, a natural question to ask is how the economy behaves in the presence of the GRPF when the decentralized equilibrium is characterized by excessive public consumption, i.e. excessive G_c. In other words, here the GRPF not only may allow higher growth via lower distortionary taxation, but may also address directly an externality. In this section we work with a utility function which implies the decentralized equilibrium is characterized by excessive G_c, for which it is the case that

$$\mathrm{MRS}_{G_c} = -\left(\frac{1-\eta-\gamma}{\eta+\gamma}\frac{G_c}{c}\right) > \mathrm{MRS}_{\mathrm{SO}}$$

Figure B1 again displays the differing MRSs in the present case, the case of excessive private consumption and under the social optimum. The utility function is written as

$$U = \frac{[c^{1-\eta-\gamma} g(G_c/C) G_c^{\eta+\gamma}]^{1-\sigma}}{1-\sigma}$$
$$g(G_c/C) \equiv (G_c/C)^{-\gamma} \tag{35}$$

We assume that $1-\eta-\gamma>0$. This utility function basically implies that private agents underestimate the marginal utility of private consumption relative to that of the public good—the congestion effect goes in the opposite direction to the previous section.

The decentralized equilibrium is characterized by the following pair of relations:

$$G_c = \frac{\eta+\gamma}{1-\eta-\gamma} C \tag{36}$$

$$G_{\mathrm{I}} = \beta Y \tag{37}$$

As suggested, the implication is that, relative to the social optimum, there is an excess of government consumption.

Under the GRPF the following pair of equilibrium relations obtain:

[12]The possibility of the two fiscal regimes delivering very similar outcomes is clearly enhanced when we have congestion in both production and consumption.

$$G_I = \beta(1-\theta)Y \quad (38)$$

$$G_c = \theta\tau(Y + rB) - rB \quad (39)$$

4.1 Simulations and Discussion of Results

Comparing Table 3 with Table 1, it is clear that, as regards the DGBC case, excessive unproductive government spending shows up in higher G_c, lower C, higher τ and lower ϕ in Table 3. Theoretically, the value function could go either way. In this case, the GRPF makes a bigger difference to the outcome in terms of reducing government consumption and the tax rate, as is expected of a restrictive fiscal rule in the presence of excessive public consumption. So the numbers clearly indicate that if a higher growth rate is the objective, then there is a strong case in favour of the GRPF when there is excessive G_c.

The larger is the value taken by γ, the stronger is the case for the GRPF. As regards the impact on welfare, the effects of higher ϕ and C attainable under the GRPF are balanced by the lower G_c, as such public services add to utility. But even here, a sufficiently large value of γ can generate quite small utility values in the DGBC case, and this can be bettered under the GRPF regime. This is clear from Table 3, part (b), where $\gamma = 0.6$ results in a utility value that is much lower than is achievable under the DGBC.

Table 3
Congested Production and Excessive G_c ((a) $\gamma = 0.1$; (b) $\gamma = 0.6$)

	DGBC	*GRPF*
(a)		
Output	2.873	2.354
Private consumption	1.083	1.237
Government consumption	0.464	0.042
Government investment	0.718	0.324
Real interest rate	0.144	0.118
Tax rate	0.438	0.192
Growth rate	0.030	0.038
Value function	–21.711	–27.603
(b)		
Output	2.873	2.354
Private consumption	0.431	1.237
Government consumption	1.723	0.042
Government investment	0.718	0.324
Real interest rate	0.144	0.118
Tax rate	0.860	0.192
Growth rate	0.000	0.038
Value function	–87.787	–27.603

Note: See Table 1 for additional parameter settings.

5 Conclusions

In this paper we attempted to analyse the effects of two different fiscal regimes on key macroeconomic variables within a framework of congestion in production and distortions to private consumption, and to relate these to the social optimum. Comparing outcomes under the DGBC, it is clear that private consumption is higher and government consumption lower when there is congestion in production and distortions to consumption than when there is congestion in production alone (what we labelled the 'benchmark case'). The GRPF regime can make a significant difference to the growth rate in the benchmark case, although the DGBC, by 'trading' more private for public consumption, comes closer to the GRPF in terms of the effects on key macroeconomic variables. We then introduced the excessive government consumption case, and found that a restrictive fiscal regime like the GRPF can bring about a significant difference to the growth rate. Despite public consumption being in the utility function, the GRPF regime, through a rise in private consumption, fall in the tax rate and rise in the growth rate, can bring about higher welfare in certain cases.

Appendix A

Numerical Solution of the Model

The models that we analyse in this paper have a simple structure (that is almost recursive) that we can exploit in our numerical calculations. First we note that, from period zero onwards, the economy always lies on the balanced growth path. Consequently, once we have found the growth rate for the economy, and given $k(0)$ and $b(0)$, we can easily solve for the path of all of the prices and quantities in our model, reducing the model ultimately to two equations in two unknowns.

We consider the case of the decentralized equilibrium under the DGBC. The other cases that we analyse in the paper result in more or less straightforward changes to this example.

Given the capital stock, $k(0)$, and the fact that $G_1(t) = \beta y(t)$, we may calculate $y(t)$ and $r(t)$ using the production technology. We then find it useful to define

$$\phi' = \frac{A(t)k(t)^{-\beta}\beta^{\beta}y(t)^{\beta} - \rho}{\sigma}$$

such that

$$\phi = [1-\tau(t)]\phi' - (\rho/\sigma)\tau(t)$$

Along the balanced growth path it follows that, for a variable $X(t)$,

$$\dot{X}(t)/X(t) = [1-\tau(t)]\phi' - (\rho/\sigma)\tau(t)$$

Hence, we may write the agent's budget constraint and the government's budget constraint as follows:

$$\{[1-\tau(t)]\phi'-(\rho/\sigma)\tau(t)\}[k(t)+b(t)]=[1-\tau(t)][y(t)+r(t)b(t)]-c(t) \quad \text{(A1)}$$

$$\{[1-\tau(t)]\phi'-(\rho/\sigma)\tau(t)\}b(t)=r(t)b(t)+[\eta/(1+\eta)]c(t)+\beta y(t)+\tau(t)[y(t)+r(t)b(t)] \quad \text{(A2)}$$

where we have used $G_I(t) = \beta y(t)$ and $G_c(t) = [\eta/(1 + \eta)]c(t)$. Equations (A1) and (A2) comprise two (nonlinear) equations in two unknowns, $c(t)$ and $\tau(t)$, and are numerically easily solved.

Appendix B

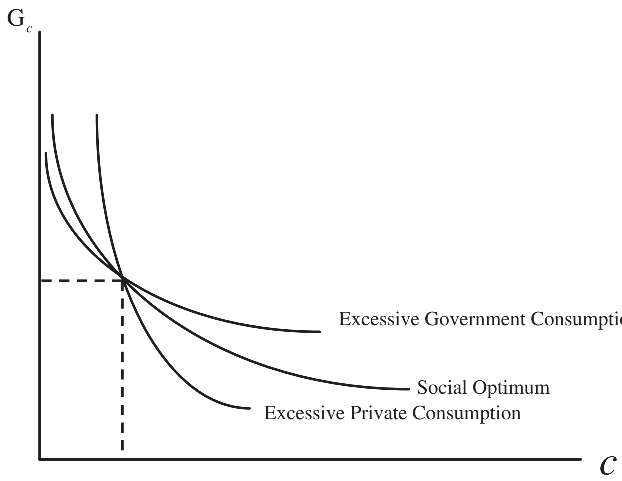

Fig. B1

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