Allocative Inefficiency of Debt Financing of Public Investment
- an Ignored Aspect of “The Golden Rule of Public Sector Borrowing”

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Abstract

In this paper we challenge the proposition that the golden rule of public sector borrowing is consistent with the principle of intertemporal allocative efficiency in the sense that growth-enhancing public investment justifies a structural public deficit. We demonstrate that in the long run the social opportunity costs of debt financed public investments exceed the social opportunity costs of tax financed public investments. Thus a benevolent government that cares about future generations and is less myopic than private households uses taxes to finance public investment. In the short run, debt financing is only justified if a considerable undersupply of public capital initially exists.

JEL-Classification: E62; H54; H60

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1. Introduction

The current budget problems of some member states of the European Union have intensified the debate surrounding the Stability and Growth Pact. The European Monetary Union (EMU) fiscal rules – instituted in the 1990s to reverse a trend of accumulating public debt and to strengthen the credibility of the Euro in its initial phase – are now being criticised as inflexible, both in terms of being an instrument of stabilisation of the cycle and also as an instrument of supply side support. A proposal for reforming the fiscal rules is that fiscal discipline in the Euro area should be based on the "golden rule of public sector borrowing", a policy design that is already applied in the United Kingdom and Germany[1]. According to the golden rule, government borrowing should not exceed government capital formation over the cycle. Thus current expenditure must be covered by current receipts while for investment expenditure recourse to debt is allowed. The adoption of the golden rule to the Treaty of Maastricht and the Stability and Growth Pact therefore suggests to exclude public investment spending from the computation of the fiscal parameters relevant to the so called "excessive deficits procedure"[2].

The supporters of the golden rule argue that such a fiscal commitment creates incentives for enforcing public infrastructure projects that may allow both growth in demand and increase in

[1] In 1997 the new labour government introduces the „Code of Fiscal Stability" in the United Kingdom. Emmersen, Frayne and Love (2003) compare the UK`s fiscal rule to the system used by countries that have adopted the Euro. The German "Bund" – see Art. 115 GG – and some German "Länder" are bound to the golden rule by constitution.

[2] In its present form, article 104 (3) of the EU-Treaty references to public investment: "If a Member State does not fulfil the requirements under one or both of these criteria, the Commission shall prepare a report. The report of the Commission shall also take into account whether the government deficit exceeds government investment expenditure and take into account all other relevant factors, including the medium-term economic

productivity (IG-Metall, 2003). The golden rule is further considered to be in line with the benefit principle of taxation or – as Musgrave (1964) calls it – the "pay as you use principle", and thus consistent with a fair intergenerational distribution (Yakita, 1994). With respect to intergenerational fairness or the contra-cyclical demand effects of public investments, it does not greatly matter whether the government invests in public consumption durables, such as operas or parks, or in productive projects that generate growth and improve the productivity of private factors. Nevertheless, the current debate on the golden rule focuses on productive public investments and the proposal of introducing the golden rule is to some extent motivated by fear that the Stability and Growth Pact is likely to depress the volume of growth enhancing public investment and thus reduces economic performance in the future (Buiter, 2001, p. 10, Balassone and Franco, 2000, Moro, 2002).

From an empirical point of view, it is difficult to divide public capital expenditure into productive and consumptive investment programs. Furthermore, some current expenditure on health or education could also be considered as growth-enhancing[3]. However, most relevant economic studies focus on public investment in infrastructure capital as highways, other transportation facilities or communication systems, owned by the public sector. The empirical evidence on the growth and productivity effects of public investment is rather clear (Gramlich, 1994). Still, the question is whether the governments choose the right projects and level of investment as well as the appropriate means of financing them and thus whether public investment decisions are efficient.

Our paper tries to contribute to this discussion, by challenging the proposition that the golden rule is consistent with the principle of intertemporal allocative efficiency in the sense that growth-enhancing public investment justifies a structural public deficit. We demonstrate that

and budgetary position of the Member State."

3 According to Wyplosz (1997, S.11) the golden rule „…is naive at best; it ignors socially productiv spending

the marginal opportunity costs of public investment depend on the finance instrument chosen by the government. Thus, the central requirement of intertemporal allocative efficiency designating, that public investment should be undertaken if the marginal social rate of return equals at least the marginal social opportunity costs says little about the efficient choice of financing public investment (Buiter, 2001). We demonstrate that a benevolent government that cares about future generations and is less myopic than private households will use taxes to finance public investment and that the allowance to finance public investments by debt does not enhance public investment. This result holds at least in the medium and long term. In the short run, financing public investment by credits only can be justified if a considerable undersupply of public capital initially exists.

The debate about the golden rule of public borrowing date bake to the German economist Lorenz von Stein (1815-1890) and the so called „Finanzklassizismus". In the 20th century the most prominent advocate of the golden rule is Musgrave (1964), who focuses on the aspect of intergenerational fairness, a problem that is recently discussed by Balassone and Franco (2000) and Kato (2002). Robinson (1998) makes some accounting issues subject of his thorough discussion of the golden rule. Buchanan (1967) and Weingast et al. (1981) discuss the item from a political economy view. They argue that debt-financed investment projects are considered less costly by voters than tax financing thus the financing instrument has a potential impact on the efficient level of public investments. The intertemporal allocative efficiency conditions of tax and debt financing are briefly discussed by Poterba (1995). Poterba (1995) neglects any interest payments cased by public debt, so that it is obvious that debt financing improves welfare in his model. The allocative efficiency is further mention by Buiter (2001), who focuses on the ongoing debate of the golden rule in the United Kingdom.

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like education which is classified as consumption, while it may include ill-desiggned investment spending."

The rest of the paper is structured as follows. In Section 2 we motivate our discussion, by describing some data for the twelve EMU member countries. Section 3 examines the implication of tax and debt financing of public investment in a neoclassical growth model both in the long run, when the economy reaches its equilibrium, and during the transition toward the steady state. To finance productive public infrastructure, the government can choose between a distorting source-based tax on capital revenue and public borrowing. First we assume the level of public investments to be exogenous and look for the financing instrument that creates less negative welfare effects. Second, we assume public investment to be endogenous and show, that debt financing reduces the efficient level of investment and the public capital stock in the steady state. Because we consider a small open economy, the interest rate is given by the world market. Therefore, the social burden of public investment is determined only by current and future taxes that are either used directly to cover the public investment expenditure or to service any debt incurred to finance the investment. Section 4 summarises our conclusions.

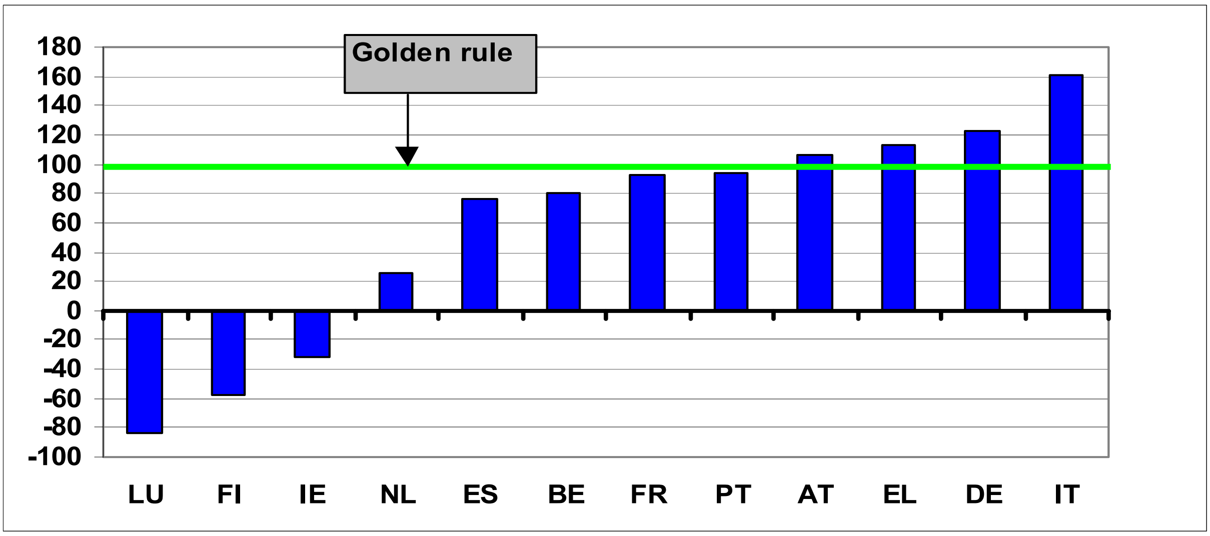
2. The debt financing rate of public investment of the EMU member countries

According to Heinemann (2002), the decline of public investment in the early nineties, watched in the OECD countries can be regarded as a consequence of a fast growing debt since the 70th. Looking at the borrowing and investment quotas of the EMU countries provides some evidence that high public borrowing does not really cause a high level of public investment. Figure 1 shows the debt financing rate defined as net borrowing of the general government as a percentage of gross fixed capital formation in these countries. Annual figures of net borrowing by the general government and gross fixed capital formation as percentage of gross domestic product (GDP) are available from the European Commission (2003). We use average values of the debt financing rate for the years 1995-2002. As seen in Figure 1, eight of the twelve EMU member countries stick to the golden rule, in the sense that net borrowing is less than 100% of gross public investment. For Austria (AT), Germany (DE), Greece (EL) and Italy (IT) the level of net borrowing exceeds the level of gross investment. In our definition Germany violated the golden rule in 6 of the 8 years considered, for three of the years the government's net borrowing exceeded 3% of GDP, thereby failing to fulfil Maastricht criteria. For all countries, the golden rule is violated 34 times in total, whereas the Maastricht criteria are only violated 22 times. For Ireland (IE), Luxembourg (LU), and Finland (FI) net borrowing is negative, thus the debt financing rate is below zero. Besides Netherlands (NL) that shows a rather small debt financing rate of 25%, the remaining four countries Belgium (BE), Greece (EL), France (FR) and Portugal (PT) are around 85%. Nevertheless Belgium (BE), Greece (EL) and Spain (ES) have achieved a rather clear change from total debt financing to nearly 100% tax financing of public investment in the past decade, whereby a relatively stable investment rate was maintained over the period observed.

Figure 2 shows the gross fixed capital formation as a percentage of GDP. Again we use averages for the years 1995-2002. It can be seen, that Austria (AT), Germany (DE) and Italy (IT) – countries where the debt financing rates are more than 100% – show low public capital formation of about 2% of GDP, respectively 2.3% for Italy. The four countries Ireland (IE), Luxembourg (LU), Finland (FI) and the Netherlands (NL) who rely mainly on tax financing show investment rates above or near 2.9%, the average investment rate of the Euro area. Luxembourg (LU), the country with the lowest debt financing rate of -83% realises the highest average investment rate of more than 4.3% of GDP. All in all, the data provides no evidence that, countries that rely heavily on debt financing engage more in public investment than others. In contrast, simple benchmarking gives the impression that countries who use current financing achieve higher investment rates.

Figure 1

Net borrowing in percentage of gross fixed capital formation (average 1995-2002)

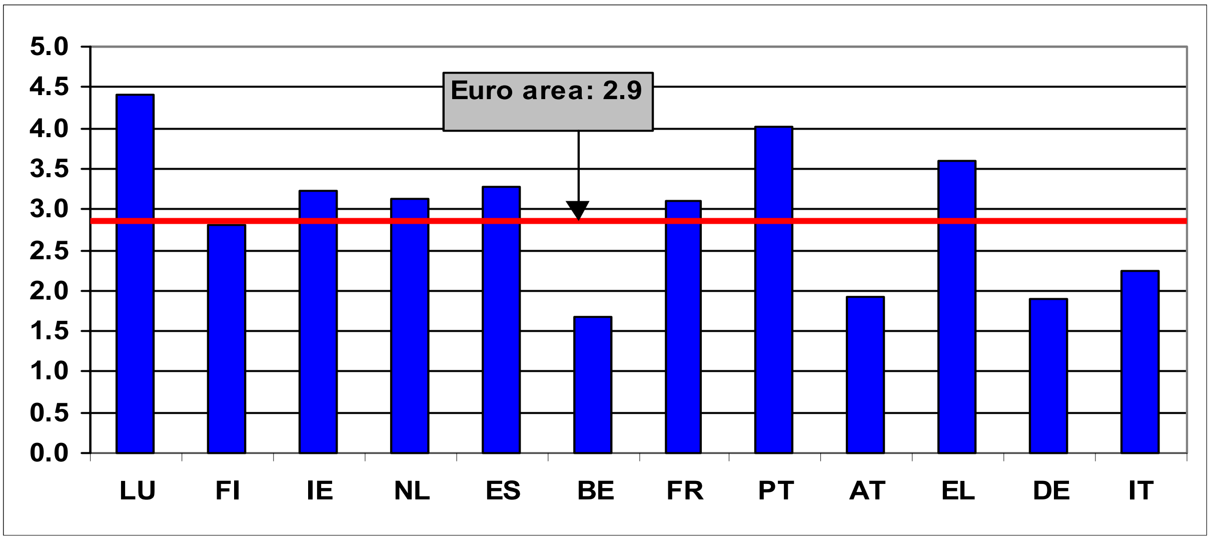


Source: See European Commission (2003) and own calculations. The debt financing rate is calculated as net borrowing of the general government as a percentage of gross fixed capital formation. Belgium (BE), Germany (DE), Greece (EL), Spain (ES), France (FR), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Austria (AT), Portugal (PT), Finland (FI).

Figure 2

Gross fixed capital formation[a] of the general government

in percentage of GDP (average 1995-2002)



[a] Gross fixed capital formation (European Statistical Accounts, ESA 1995, 3.102) consists of resident producers' acquisitions, less disposals of fixed assets during a given period plus certain additions to the value of non-produced assets realized by the productive activity of producer or institutional units. Differentiation is made between equipment and construction.

Nevertheless, Calderon, Easterly and Seven (2002) report that the period of fiscal austerity that most of Latin American countries underwent during the eighties and nineties was characterised by a sharp contradiction in infrastructure spending. According to Balassone and Franco (2000) the link between fiscal consolidation and cuts in capital spending is also confirmed by the experience of EU countries. Poterba (1995) presents some empirical findings for 48 American states, suggesting that tax financing of public capital projects are associated with lower levels of capital spending. However, these results should not be misinterpreted as a causality direction in the sense that funding public investment from current revenues causes a reduction in public investment. We rather assume that high public debt forces fiscal consolidation and in return lead to a cut in public spending mainly to the expends of public investment. Thus the link between consolidation and the slowdown of public investment should be interpreted as a problem of simultaneity in countries that show a shortcoming of fiscal health. Actually, Tempel (1994) shows for the American state and local level that public investment decisions are not greatly but still negatively affected by the level of debt financing.

3. The model

We discuss a growth model where the world interest rate r^* is exogenious. The burden of public investment is therefore determined only by current and future taxes, and we do not consider the controversial crowding out effect of public debt described by Modigliani (1961). Business cycles or any shocks are also neglected. In the small open economy the government is a price-taker and, according to the neoclassical approach, seeks to promote social welfare. Public decision-makers cannot directly control private investment or consumption but influence it through their tax instruments and the supply of productive infrastructure. Thus our model is in line with the so-called “second-best shadow pricing approaches” (Atkinson and Stiglitz, 1980, Diamond, 1968, Sandmo and Drèze, 1971, Marchand and Pestieau, 1984). The markets for goods and inputs are perfectly competitive and goods as well as private capital are perfectly mobile across borders.

There are three factors of production: private capital K_t, labour L_t, and public capital G_t, which are used by private firms to produce one homogeneous good Y_t. The price of Y_t is normalised to unity. Capital is simply non-consumed output. The production function $F(K_t,L_t,G_t) = Y_t$ exhibits positive diminishing marginal products with respect to each input, the Inada conditions hold, and technical progress is neglected. The public capital stock yields only production benefits, so that consumers are not immediate beneficiaries of public capital. We further assume that the production function exhibits constant returns at least in K_t and L_t. It is therefore concave and homogeneous of a degree ≤ 1 in the private factors.

The public input can be interpreted as a publicly provided private good if the production function is homogeneous to a degree 1 in K_t, L_t, and G_t together. In this case – according to Euler’s theorem – total output can be decomposed into the imputed shares of private capital, government capital and labour. Yet because the government supplies its services free of charge, national income is not exhausted if private inputs are paid its marginal product. In the following, we assume that the factor of labour has some way to appropriate the public inputs' benefits and convert them into private wage income. Private capital is thus paid its marginal product (Gramlich, 1994).

Private capital has two costs to the firms, the rental price r_t and a source-based tax on capital revenue, where τ_t denotes the capital tax rate. The firms invest capital up to the point where the marginal revenue of private investment equals the costs:

$$\frac{\partial F_t(K_t, L_t, G_t)}{\partial K_t} = \frac{r_t}{1 - \tau_t}. \tag{1}$$

Since firms are free to invest and produce domestically or abroad, the net of tax return of capital is the same everywhere $r_t = r^*$ and the supply of capital is completely price elastic. The marginal productivity of private capital equals $r^*/(1-\tau_t)$, so the share of domestic income received by private capital is $K_t r^*/(1-\tau_t)$ and the aggregate domestic wage income W_t is a residual given by

$$Y_t - K_t \frac{r^*}{(1 - \tau_t)} = W_t. \tag{2}$$

The household sector is designed according to the overlapping-generations model. All people live for two periods, so at each point in time there are an old and a young generation living side by side. An individual born at time t supplies a fixed amount of labour and receives a wage income $w_t = W_t/L_t$. From the perspective of the private agents, the fiscal parameters G_t and τ_t are exogenous. Each young person consumes c_t of the wage income and saves the remainder $s_t = w_t - c_t^y$. In the second period of his life the individual consumes all his wealth, both interest and principal $s_t(1 + r^*) = c_{t+1}^o$. Like firms, private households have access to the world capital market so r^* is the return on private saving. Domestic and foreign claims on capital are assumed to be perfect substitutes as stores of value and no residence based tax on capital income is levied.

The decision problem for young people is to maximise the well-behaved utility function $u_t = u(c_t^y, c_{t+1}^o)$ subject to the private budget constraint

$$c_t^y = w_t - \frac{c_{t+1}^o}{(1+r^*)} . \tag{3}$$

The first-order condition for a private utility maximum is $\frac{\partial u}{\partial c_{t+1}^o} \Big/ \frac{\partial u}{\partial c_t^y} = \frac{1}{1+r^*}$. We assume that $u_t = u\,(c_t^y, c_{t+1}^o)$ is homothetic in first and second-period consumption. With homothetic preferences and an unchanging interest rate, the consumer always spends a constant fraction of lifetime wealth on first period consumption.

The budget constraint of the public sector is given by

$$G_{t+1} - G_t - B_{t+1} + (1+r^*)B_t - K_t \frac{r^*}{(1-\tau_t)} \tau_t = 0 . \tag{4}$$

Public consumption is neglected in the model, thus public expenditure consists of investment $(G_{t+1} - G_t)$ – no depreciation is considered – and debt service r^*B_t. B_t is the government interest bearing debt at the end of period t that leads to the debt service r^*B_t in period t+1[4]. The only tax levied is the source-based capital tax where total tax collection is given by $K_t \tau_t r^* /(1-\tau_t)$. In period t the tax revenue plus public borrowing equals the net investment plus the debt service.

According to the golden rule, public borrowing can not exceed public investment. Therefore, in each period the tax revenue must at least cover the debt service. The tax revenue θ_t that exceeds the debt service is used to finance public investment

[4] Poterba and Rueben (1999) show how the economic health of US states, measured by unemployment rates, state fiscal rules, and the level of outstanding debt affect the borrowing costs of the public sector. States with strict anti-deficit fiscal conditions pay less to issue new debt. Nevertheless, this aspect is neglected in the model.

$$K_t \frac{\tau_t r^*}{(1-\tau_t)} - r^* B_t = \theta_t . \quad (5)$$

Thus θ_t denotes tax financed public investment. From (5) we derive the intertemporal budget constraint and the transversality condition $\lim_{T\to\infty}\left[\frac{1}{1+r^*}\right]^T B_{t+T} = 0$.

3.1. Opportunity Costs of Tax - and Debt Financing

Since we seek the optimal tax and investment strategy of the government it is necessary to specify a criterion function by which optimality can be judged. Therefore we assume that the government has the objective to maximise the utility of its residents and discounts the utility of future generations at rate λ. This implies a social welfare function of the form $\Psi = u(c_1^o) + \sum_{t=1}^{\infty} (1+\lambda)^{1-t} u_t(c_t^y, c_{t+1}^o)$. If the government cares less about future generations, λ is positive and Ψ converges under the condition of a stationarity assumption of u_t. The government maximises the welfare function subject to the private constraints (2) and (3), the optimality condition of the private household, the public budget constraint and (5) and the golden rule of public sector borrowing $(1+n)b_{t+1}-b_t \leq (1+n)g_{t+1}-g_t$. An additional constraint holds that G_1 and B_1 are given. Accordingly, the Lagrangian expression is

$$\begin{aligned}\Gamma(\theta_t, B_{t+1}, G_{t+1}, c_t^y, K_t) = \Psi + \sum_{t=1}^{\infty} \mu_t \left[B_{t+1} - B_t + \theta_t - G_{t+1} + G_t\right] \\ + \sum_{t=1}^{\infty} \rho_t \left[Y_t - W_t - K_t r^* - (\theta_t + r^* B_t)\right] + \sum_{t=1}^{\infty} \delta_t \left[\frac{W_t}{L_t} - c_t^y - \frac{c_{t+1}^o(c_t^y)}{(1+r^*)}\right]\end{aligned} \quad (6)$$

where the Lagrange multipliers μ_t, ρ_t, and δ_t are functions of t. Eliminating ρ_t, and δ_t we get the shadow value of a tax-Euro

$$\mu_t \leq \frac{(1+\lambda)^{-t} \frac{\partial u}{\partial c_t^y} \frac{1}{L_t} \left[\frac{\partial W_t}{\partial K_t} \right]}{\left[\frac{\partial W_t}{\partial K_t} - \frac{r^* \tau_t}{(1-\tau_t)} \right]} \tag{7}$$

and the shadow value of a debt- Euro

$$\mu_t \leq r^* \sum_{i=1}^{\infty} \frac{(1+\lambda)^{-(t+i)} \frac{\partial u}{\partial c_{t+i}^y} \left[\frac{\partial (W_{t+i} / L_{t+i})}{\partial K_{t+i}} \right]}{\left[\frac{\partial W_{t+i}(G_{t+i}, K_{t+i})}{\partial K_{t+i}} - \frac{r^* \tau_{t+i}}{(1-\tau_{t+i})} \right]} . \tag{8}$$

Both shadow values rise with the tax rate. It becomes apparent that the burden of debt financing must not be borne by the generation young in period t where debt is accumulated, but by the generations young in later periods (t+i) for $i = 1 \ldots \infty$. Compared to that the burden of tax financing crops up fully in period t. Since public investment produces deferred benefits, the means of financing them can affect intergenerational distribution. Tax financing implies a welfare loss for the generation young in period t, because it fully pays for investment that benefits will increase the wage income of future generations. Nevertheless, with more or less homogeneous public investment flows, this aspect of intergenerational equity looses importance.

A benevolent government chooses that financial instrument that creates the lower shadow price. Thus debt financing will only be chosen, if

$$r^* \leq \frac{\delta_t}{\delta_{t+1}}(1+n)\frac{\left[\frac{\partial W_t}{\partial K_t}\right]\left[\frac{\partial W_{t+1}(G_{t+1},K_{t+1})}{\partial K_{t+1}} - \frac{(\theta_{t+1}+r^* B_{t+1})}{K_{t+1}}\right]}{\left[\frac{\partial W_{t+1}}{\partial K_{t+1}}\right]\left[\frac{\partial W_t(G_t,K_t)}{\partial K_t} - \frac{(\theta_t+r^* B_t)}{K_t}\right]} - 1 \qquad (9)$$

holds. In the long run this condition is violated for $r^* > (1+\lambda)(1+n)-1$. Because the benevolent government is supposed to be less myopic than the rest of the world and thus λ is assumed to be rather small, debt financing can be considered as an inferior instrument to finance public investment.

Using the derivation of G_{t+1} we get the shadow benefit of the public input. In the optimum the shadow benefit of the public input equals the shadow value of a Euro absorbed by the public sector, thus the shadow profit becomes zero. Moreover, it can be shown that the second best solution depends on the precise set of financing instruments which is at the disposable of the government.

The social marginal opportunity costs of public investment can be expressed, eliminating μ_t. They depend on the financing instrument, as is shown by the right-hand side of the following inequality conditions (10) and (11). According to the Kuhn-Tucker conditions the optimality constraints can be expressed as:

$$\left[\frac{\partial Y_{t+1}(G_{t+1},K_{t+1})}{\partial G_{t+1}}\right] \leq (1+\lambda)(1+n)\frac{\dfrac{\partial u}{\partial c_t^y}\left[\dfrac{\partial W_t}{\partial K_t}\right]}{\dfrac{\partial u}{\partial c_{t+1}^y}\left[\dfrac{\partial W_{t+1}}{\partial K_{t+1}}\right]}\frac{\left[\dfrac{(\theta_{t+1}+r^* B_{t+1})}{K_{t+1}}-\dfrac{\partial W_{t+1}(G_{t+1},K_{t+1})}{\partial K_{t+1}}\right]}{\left[\dfrac{(\theta_t+r^* B_t)}{K_t}-\dfrac{\partial W_t(G_t,K_t)}{\partial K_t}\right]} - 1 + \frac{\dfrac{\partial W_{t+1}}{\partial G_{t+1}}}{\left[\dfrac{\partial W_{t+1}}{\partial K_{t+1}}\right]}\left[\frac{(\theta_{t+1}+r^* B_{t+1})}{K_{t+1}}\right] \tag{10}$$

$$\theta_t \geq 0 ; \qquad \theta_t \frac{\partial \Gamma}{\partial \theta_t} = 0$$

$$\left[\frac{\partial Y_{t+1}(G_{t+1},K_{t+1})}{\partial G_{t+1}}\right] \leq r^* + \frac{\dfrac{\partial W_{t+1}}{\partial G_{t+1}}}{\dfrac{\partial W_{t+1}}{\partial K_{t+1}}}\left[\frac{(\theta_{t+1}+r^* B_{t+1})}{K_{t+1}}\right] \tag{11}$$

$$B_{t+1} - B_t \geq 0 ; \qquad (B_{t+1} - B_t)\frac{\partial \Gamma}{\partial B_{t+1}} = 0$$

From (11) it can be seen that the opportunity costs include the market price of public investment r^* plus the excess burden incurred by shifting money from the private to the public sector. Thus in the case of debt financing the social opportunity costs are not equal to the marked price of capital r^*[5]. The left hand side of the inequality conditions represents the partial marginal productivity of public capital. For a constant output elasticity of private capital, we get the Arrow (1982) result stating that the government equalises the marginal productivity of private and public capital $\partial Y_{t+1} / \partial G_{t+1} = r^* /(1-\tau_{t+1})$.

[5] An exception is the case of a non-distorting tax, where no excess burden accrues and the opportunity costs of debt financed public investments are simply r^*.

Which conclusions can be drawn from the inequality constraints (11) and (12)? From (11) we see that if

$$r^* < (1+\lambda)(1+n)\frac{\frac{\partial u}{\partial c_t^y}}{\frac{\partial u}{\partial c_{t+1}^y}} - 1 \qquad (12)$$

holds, $\theta_t = 0$ must hold too, otherwise condition (10) is not met. In this case, the government chooses the mean of debt financing, as long as there is no over-accumulation of public capital. If the benevolent government gives nearly equal weight to the utility of present and future generations the social discount rate λ converges to zero. Under the made assumption of a homothetic private utility function and for a constant output elasticity of private capital the inequality constraint (12) can be approximated as $(1+r^*) < Y_{t+1}/Y_t$. Therefore, the growth rate of aggregate output, induced by public investment must be higher than r^*, to make borrowing an efficient instrument to finance that investment.

If the government is for whatever reason restricted to debt financing, the economy achieves the welfare maximising steady state in period (t+1). If not, restriction (12) is violated in period (t+1) for $r^* > (1+\lambda)(1+n) - 1$. Because we assume in this normative analyses that $r^* > (1+\lambda)(1+n) - 1$ holds, the benevolent government will never choose public debt as an instrument to finance public investment in the long run. At least from period (t+2) on, the social opportunity costs of tax financing are lower than the opportunity cost of debt financing. Restriction (10) thus becomes the binding constraint and a switch from debt to tax financing is welfare improving.

3.2. Long term effects of debt financing

Borrowing leads to higher opportunity costs and thus to lower public investment and a lower public capital stock in the long run. This can be seen in Table 1, where the relevant aggregates are expressed in per capita units. For the sake of simplicity the production function is specified in the form $F(K_t, L_t, G_t) = K_t^{\alpha} L_t^{\beta} G_t^{\varepsilon}$, where α, β and ε are the output elasticities, with $\alpha + \beta + \varepsilon = 1$. Local properties of the steady state equilibrium are studied in the Appendix. The first order conditions (1), (10), (11) and the public budget constraint (4) imply that there exists one steady state for the case of tax financing as well as debt financing.

Table 1

Steady state values of relevant variables

Tax financing	Debt financing
$k_{TAX} = \left(\left(\frac{\alpha(1-\tau)}{r^*} \right)^{1-\varepsilon} \left(\frac{\varepsilon(1-\tau)}{(1+\lambda)(1+n)-1} \right)^{\varepsilon} \right)^{\frac{1}{1-\alpha-\varepsilon}}$	$k_{DEBT} = \left(\left(\frac{\alpha(1-\tau)}{r^*} \right)^{1-\varepsilon} \left(\frac{\varepsilon(1-\tau)}{r^*} \right)^{\varepsilon} \right)^{\frac{1}{1-\alpha-\varepsilon}}$
$g_{TAX} = \left(\left(\frac{\alpha(1-\tau)}{r^*} \right)^{\alpha} \left(\frac{\varepsilon(1-\tau)}{(1+\lambda)(1+n)-1} \right)^{1-\alpha} \right)^{\frac{1}{1-\varepsilon-\alpha}}$	$g_{DEBT} = \left(\left(\frac{\alpha(1-\tau)}{r^*} \right)^{\alpha} \left(\frac{\varepsilon(1-\tau)}{r^*} \right)^{(1-\alpha)} \right)^{\frac{1}{1-\alpha-\varepsilon}}$
$y_{TAX} = \left(\left(\frac{\alpha(1-\tau)}{r^*} \right)^{\alpha} \left(\frac{\varepsilon(1-\tau)}{(1+\lambda)(1+n)-1} \right)^{\varepsilon} \right)^{\frac{1}{1-\alpha-\varepsilon}}$	$y_{DEBT} = \left(\left(\frac{\alpha(1-\tau)}{r^*} \right)^{\alpha} \left(\frac{\varepsilon(1-\tau)}{r^*} \right)^{\varepsilon} \right)^{\frac{1}{1-\alpha-\varepsilon}}$
$w_{TAX} = (1-\alpha) \left(\left(\frac{\alpha(1-\tau)}{r^*} \right)^{\alpha} \left(\frac{\varepsilon(1-\tau)}{(1+\lambda)(1+n)-1} \right)^{\varepsilon} \right)^{\frac{1}{1-\alpha-\varepsilon}}$	$w_{DEBT} = (1-\alpha) \left(\left(\frac{\alpha(1-\tau)}{r^*} \right)^{\alpha} \left(\frac{\varepsilon(1-\tau)}{r^*} \right)^{\varepsilon} \right)^{\frac{1}{1-\alpha-\varepsilon}}$
$\tau_{TAX} = \frac{\varepsilon}{\left(\frac{\alpha((1+\lambda)(1+n)-1)}{n} + \varepsilon \right)}$	$\tau_{DEBT} = \frac{\varepsilon}{\alpha + \varepsilon}$

Because the income share of the public capital is appropriated by the factor labour, wage income w_t equals $(1-\alpha)y_t$. The steady state values have no time index. The indices DEBT and TAX indicate debt – respectively, tax financing. From the public budget constraint (4) we know that if the government uses borrowing to finance public investment, the golden rule states that tax revenue covers the public interest payments $\tau_{DEBT}\alpha y_{DEBT} = r^* b_{DEBT}$ and, the public per capita capital stock converges to the public per capita debt, so that $b_{DEBT} = g_{DEBT}$ and $\tau_{DEBT}\alpha y_{DEBT} / r^* = g_{DEBT}$ holds in the long run. If the government applies the mean of tax financing $(1+n)b_{TAX,t} - b_{TAX,t-1} = 0$ holds, the public budget constraint can be expressed as $(1+n)g_{TAX,t+1} - g_{TAX,t} + r^* b_0/(1+n)^t = \tau_{TAX}\alpha y_{TAX}$ and the capital tax revenue is $\tau_{TAX} = (n\, g_{TAX})/(\alpha y_{TAX})$. According to (10) and (11) the optimal capital tax rates τ_{TAX} and τ_{DEBT} are shown in Table 1. For $r^* > (1+\lambda)(1+n)-1$, τ_{TAX} is always lower than the optimal capital tax rate τ_{DEBT}. Thus the private sector bears higher tax rates in the case of debt financing than in the case of tax financing.

On the other hand, the supply of public capital g is lower in the case of debt financing. Therefore we have two negative effects on private capital formation caused by public borrowing: first, higher tax rates that lead to a higher outflow of private capital; and secondly, lower public capital supply leading to a weaker compensation of private capital outflows. As a result, the private capital stock k_{DEBT} is lower than k_{TAX}. Because private and public capital formation is higher in the case of tax financing, output $y_{TAX} > y_{DEBT}$ and wage income $w_{TAX} > w_{DEBT}$ are also lower in the case of debt financing.

4. Conclusion

According to the golden rule of public sector borrowing, government borrowing should not exceed government capital formation over the cycle. Thus current expenditure must be covered by current receipts while for investment expenditure recourse to debt is allowed. In recent years, the golden rule has been suggested to modify and loosen the EMU fiscal rules. It has been argued that the Treaty of Maastricht and the Stability and Growth Pact may reduce public sector contribution to capital accumulation and that the implementation of the golden rule may prevent an investment slowdown in the public sector of the EMU member countries. In this paper, we challenge the proposition that the golden rule and the allowance for debt financing of public investment enhances public investment. On the contrary, we argue, that public borrowing is not an efficient instrument to finance public investment by examining how debt financing of public investment affects social welfare and the stock of public and private capital.

Public capital is considered to positively influence the private factor productivity, and thus is provided by the jurisdictional government in order to improve labour productivity and accommodate mobile capital. We demonstrate that a benevolent government that cares about future generations and is less myopic than private households uses taxes to finance public investment, because debt financing increases the opportunity costs of public investments and decreases public investment and the public capital stock. Beyond it, higher public capital costs must be covered by higher tax revenue. In an open economy, a higher tax burden on mobile capital leads to a higher outflow of private capital. This result holds at least in the medium and long term. In the short run, financing public investment by borrowing can be justified if a considerable undersupply of public capital initially exists so that public investment give raise to considerable transitory growth effects.

Appendix

In the case of tax financing of public investments exists a stable equilibrium region around a steady state g if there exists a neighbourhood of g such that if the initial capital stock g_0 is in this neighbourhood, then the public capital stock converges to g. If g converges to a finite value, the transversality condition is satisfied. The optimality conditions (10) and the public budget constraint (4) imply that

A1) $$P(g_t, g_{t+1}, g_{t+2}) = -h(g_t, g_{t+1}, g_{t+2})\frac{\partial u}{\partial c^y_{t+1}} + \frac{\partial u}{\partial c^y_t} = 0, \text{ where}$$

$$h(g_t, g_{t+1}, g_{t+2}) = -\frac{1 + \frac{\partial y_{t+1}}{\partial g_{t+1}}\left[1 - \frac{(1+n)g_{t+2} - g_{t+1}}{\beta y_{t+1}}\right]}{(1+\lambda)(1+n)}$$

A steady state capital stock g is a solution of $h(g_t, g_{t+1}, g_{t+2}) = 1$. The question is, whether the system converges to this steady state. When stability is verified, equation (10) is sufficient to determine the equilibrium.

First we linearize A1) around the steady state:

A2) $$\frac{\partial P}{\partial g_t}(g_t - g) + \frac{\partial P}{\partial g_{t+1}}(g_{t+1} - g) + \frac{\partial P}{\partial g_{t+2}}(g_{t+2} - g) = 0.$$

In non-degenerated cases, the stability of the non-linear difference equation (10) is equivalent to the stability of the linear equation A2) in some neighbourhood of a steady state (Ni and Wang, 1995).

$$\frac{\partial P(g)}{\partial g_t} = -\frac{\partial h(g)}{\partial g_t}\frac{\partial u}{\partial c_{t+1}^y} + \frac{\partial \frac{\partial u}{\partial c_{t+1}^y}}{\partial c_{t+1}^y}\frac{\partial c_{t+1}^y}{\partial g_t} - \frac{\partial \frac{\partial u}{\partial c_t^y}}{\partial c_t^y}\frac{\partial c_t^y}{\partial g_t} > 0$$

$$\frac{\partial P(g)}{\partial g_{t+1}} = -\frac{\partial h(g)}{\partial g_{t+1}}\frac{\partial u}{\partial c_{t+1}^y} + \frac{\partial \frac{\partial u}{\partial c_{t+1}^y}}{\partial c_{t+1}^y}\frac{\partial c_{t+1}^y}{\partial g_{t+1}} - \frac{\partial \frac{\partial u}{\partial c_t^y}}{\partial c_t^y}\frac{\partial c_t^y}{\partial g_{t+1}} < 0$$

$$\frac{\partial P(g)}{\partial g_{t+2}} = -\frac{\partial h(g)}{\partial g_{t+2}}\frac{\partial u}{\partial c_{t+1}^y} + \frac{\partial \frac{\partial u}{\partial c_{t+1}^y}}{\partial c_{t+1}^y}\frac{\partial c_{t+1}^y}{\partial g_{t+2}} > 0$$

Now, we define a quadratic function $\Phi(\zeta) = \frac{\partial P}{\partial g_t} + \frac{\partial P}{\partial g_{t+1}}\zeta + \frac{\partial P}{\partial g_{t+2}}\zeta^2$, which solutions are always real. Since $\frac{\partial P(g)}{\partial g_{t+1}} > 0$ and $\frac{\partial P(g)}{\partial g_{t+2}} < 0$ and $\frac{\partial P(g)}{\partial g_t} < 0$ both roots are positive. One root is larger than one and the second root is smaller than one. Since $0 < \zeta_1 < 1 < \zeta_2$ holds the steady state g is local stable or a saddle.

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