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Debt financing of public investment: On a popular misinterpretation of "the golden rule of public sector borrowing"

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Abstract

In this paper I 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. I demonstrate that in the long run the social opportunity cost of debt-financed public investment exceeds the social opportunity cost of tax financed public investments. This result holds if the social rate of time preference is lower than the interest rate on government borrowing. Thus a benevolent government would use taxes to finance public investment. In the short run, debt financing is justified if public investment has a considerable growth effect on private consumption. This requires a corresponding initial undersupply of public capital.

JEL classification: E62; H54; H60
Keywords: Public investment; Public borrowing; Golden rule; Budget rules; Stability and Growth Pact

1. Introduction

The budget problems of some member states of the European Union have initiated a controversial debate surrounding the Stability and Growth Pact. The Economic and Monetary Union's (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 – has been criticized as inflexible, both as being an instrument of stabilization of the cycle and also as an instrument of

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supply side support. The outcome of this discussion is the recent change of the Stability and Growth Pact[1] that above all affects the implementation of the excessive deficit procedure.[2] In contrast to the earlier arrangement, exceeding the 3% reference value as the maximum value for the annual government budget deficit can be justified by a number of so-called "relevant factors", in particular public investment (see European Commission, 2005).[3]

The special treatment of capital expenditure points to the "golden rule of public sector borrowing". According to this fiscal rule, government deficit is accepted if accompanied by an increase in assets so that the government's net asset position does not deteriorate. Thus current expenditures must be covered by current receipts while for investment expenditure recourse to debt is allowed.[4]

The supporters of the golden rule argue that debt financing of public investment creates incentives for providing public infrastructure projects that contribute both to growth in demand and increased productivity (see DGB, 2003). Kopits (2001) proposes that the golden rule can be considered as a "growth oriented" fiscal rule that avoids placing an undue burden of compliance with certain types of fiscal policy rules on cuts in government investment spending. Debt financing of public investment is further considered to be in line with the benefit principle of taxation or – as Musgrave (1939) calls it – the "pay as you use principle", and thus is consistent with a fair intergenerational distribution (see Yakita, 1994). If current expenditure is financed through taxation and investment is financed through borrowing, current taxpayers pay for current spending but future generations bear the cost of borrowing, as it will be they who gain from investment.[5]

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 private factor productivity. Nevertheless, the debate on the golden rule focuses on productive public investment. In particular, the special treatment of public investment in the Stability and Growth Pact is to some extent motivated by fear that the EMU fiscal rules are likely to depress the

[1] On 20 March 2005 the Ecofin Council adopted a report to the Heads of State or of Government entitled "Improving the implementation of the Stability and Growth Pact". On March 22nd and 23rd 2005 the European Council endorsed this report, stating that it updates and complements the Stability and Growth Pact.

[2] For further details, see Deutsche Bundesbank (2005).

[3] Article 104 (3) of the EC Treaty refers 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 and budgetary position of the Member State."

[4] In the United Kingdom and Germany the government's deficit-limiting budget rules basically follow the golden rule. The golden rule is part of the "Code of Fiscal Stability" introduced by the government in the United Kingdom in 1997. The code states that over the economic cycle the government will only borrow to invest and not to fund current expenditure (see HM Treasury, 1998). Emmerson et al. (2003) compare the UK's fiscal rule to the system used by countries that have adopted the euro. Article 115 of German Basic Law as well as the constitutions of the individual German states are also orientated according to the golden rule, although there are problematic aspects concerning the way this budgetary rule is implemented in Germany (see Deutsche Bundesbank, 2005). Kopits and Symansky (1998) cite other countries that introduced balanced-budget rules of the golden rule type.

[5] The aspect of intergenerational fairness was recently discussed by Balassone and Franco (2000) and Kato (2002). Buchanan (1967) and Weingast et al. (1981) discuss the topic from a political economy viewpoint. They argue that debt-financed investment projects are considered less costly by voters than tax financing. Therefore the financing instrument has a potential impact on the efficient level of public investments. Peletier et al. (1999) argue that a golden rule could help to avoid the tendency towards strategic underinvestment.

volume of growth-enhancing public investment and thus to reduce economic performance in the future (see Buiter, 2001; Balassone and Franco, 2000; Moro, 2002). In this context the golden rule is not only understood as an upper limit to public sector borrowing but is often misinterpreted with regard to the way that debt financing is an efficient instrument for financing public investment.

From an empirical point of view, it is difficult to divide public capital expenditure into productive and consumptive investment. In addition, some current expenditure on health or education could also be considered to be growth-enhancing.[6] However, most economic studies focus on public investment in infrastructure such as highways and other transportation facilities or communication systems owned by the public sector. In recent empirical analysis, different methodologies have been followed to investigate the impact of public investment on economic activities. In most of this research, measures of public investment are found to increase aggregate output. Yet there are exceptions (see Romp and de Haan, 2005). However, if certain public investment is assumed to be growth enhancing, the question remains whether governments choose the right projects and the right level of investment or the appropriate means of finance, and whether public investment decisions are efficient.

This paper contributes to this discussion by challenging the proposition that debt financing of public investment is consistent with the principle of intertemporal allocative efficiency in the sense that growth-enhancing public investment justifies a structural public deficit. I demonstrate that the marginal opportunity cost of public investment depends on the finance instrument chosen by the government. Thus, the central requirement of intertemporal allocative efficiency, which is that public investment should be undertaken if the marginal social rate of return equals at least the marginal social opportunity cost, says little about the efficient choice of financing public investment (see Buiter, 2001).[7]

The rest of the paper is structured as follows. Section 2 sets out the empirical context for our discussion. 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 transition toward the steady state. To finance productive public infrastructure, the government can choose between a distorting source-based tax on capital, a lump sum tax, and public borrowing. Since we consider a small open economy, the interest rate is determined in the world market. Section 4 summarizes the conclusions.

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

In this section I set out the empirical context of the problem by describing data for the EMU member countries and the United Kingdom. Although I discuss a normative question in a theoretical context, simple benchmarking applies the problem to an empirical background. The borrowing and investment quotas of EMU countries provide evidence that high public borrowing does not particularly cause a high level of public investment.

[6] According to Wyplosz (1997) the golden rule "...is naive at best; it ignores socially productive spending like education which is classified as consumption, while it may include ill-designed investment spending". For the Deutsche Bundesbank (2005) the golden rule appears essentially plausible but serious reservations must be voiced with regard to its implementation. Robinson (1998) makes accounting issues the subject of his thorough discussion of the golden rule.

[7] Buiter (2001) focuses on the ongoing debate on the golden rule in the United Kingdom. The intertemporal allocative efficiency conditions of tax and debt financing are briefly discussed by Poterba (1995). He neglects any interest payments on public debt, so that it is obvious that debt financing improves welfare in his model.

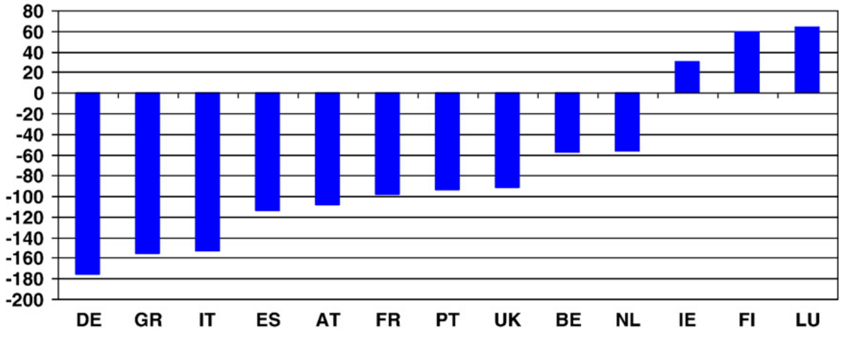

Fig. 1. Net lending (+) or net borrowing (−) of the general government in percentage of gross fixed public capital formation (average annual rates 1995–2004). For Spain, the time period considered is only until 1999, because Eurostat did not publish data for gross fixed public capital formation for the years 2000–2004. Source: See Eurostat and own calculations. Germany (DE), Greece (GR), Italy (IT), Spain (ES), Austria (AT), France (FR), Portugal (PT), United Kingdom (UK), Belgium (BE), Netherlands (NL), Ireland (IE), Finland (FI), Luxembourg (LU).

The ESA 95 statistical definition of public investment is the gross fixed capital formation of the general government.[8] This definition includes investments carried out by the central government and by local authorities. With regard to the contribution of the stock of public capital, a distinction should be drawn between gross and net investment by the public sector. Only the concept of net investment is the correct measure of the actual change in value of the stock of public capital, by taking depreciation into account. That is, the loss of economic value of the current capital stock due to usage or obsolescence. However, it is common to refer to the statistical aggregate “gross fixed capital formation of the general government” to obtain country-level information on public investment (see European Commission, 2003).[9]

Fig. 1 shows the debt-financing rate defined as net borrowing of the general government as a percentage of gross fixed public capital formation in the EMU countries and the United Kingdom. Annual figures of net borrowing by the general government and gross fixed public capital formation are available from Eurostat. We use average values of the annual debt-financing rate for the years 1995–2004. As seen in Fig. 1, in seven of the twelve EMU member countries as well as in the United Kingdom, net borrowing is less than 100% of gross public investment. For Germany (DE), Greece (GR), Italy (IT), Spain (ES), and Austria (AT), the level of net borrowing exceeds the level of gross public investment. In case of Germany, net borrowing of the general government goes beyond gross fixed public capital formation in 8 out of 10 years. For 5 of the years considered, the government’s net borrowing exceeded 3% of GDP, thereby failing to fulfil Maastricht criteria. For all countries net borrowing exceeds investment in the public sector 56 times in total, whereas the 3% reference value of Maastricht is only violated 43 times. For Luxembourg (LU), Finland (FI), and Ireland (IE), net borrowing is negative, and thus the debt-financing rate is above zero. Besides the Netherlands (NL) and Belgium (BE), which show rather small debt financing rates of

[8] Gross fixed capital formation 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 (see ESA, 1996, 3.102).

[9] According to the European Commission (2003), the available statistics on net investment are the result of estimation methods and are of limited reliability.

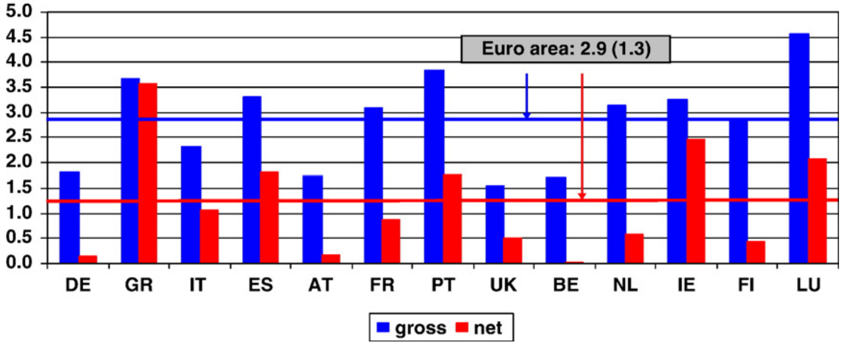

Fig. 2. Fixed public capital formation of the general government in percentage of GDP (average annual rates 1995–2004). Source: See Eurostat and own calculations.

56% and 57%, the remaining three countries United Kingdom (UK), Portugal (PT), and France (FR) show rates between 90% and 97%.

With respect to net fixed public capital formation, for which quantification is obtained by subtracting depreciation from gross fixed capital formation, the proportions are even clearer. Net borrowing of the general government exceeds net fixed capital formation in the period 1995–2004 in all countries considered except Luxembourg, Ireland, and Finland. Annual figures of public depreciation and gross domestic product (GDP) are also available from Eurostat.

Fig. 2 shows the gross and net fixed public capital formation as a percentage of GDP. Again we use averages for the years 1995–2004. It can be seen that Austria (AT), Germany (DE) and Italy (IT) – countries where the debt financing rates are over 100% – show low gross fixed public capital formation between 1.7% and 2.3% of GDP. Luxembourg (LU), Finland (FI), Ireland (IE), and the Netherlands (NL), which 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 +65% realizes the highest average investment rate of more than 4.6% of GDP. Overall the data provide no evidence that countries that rely heavily on debt

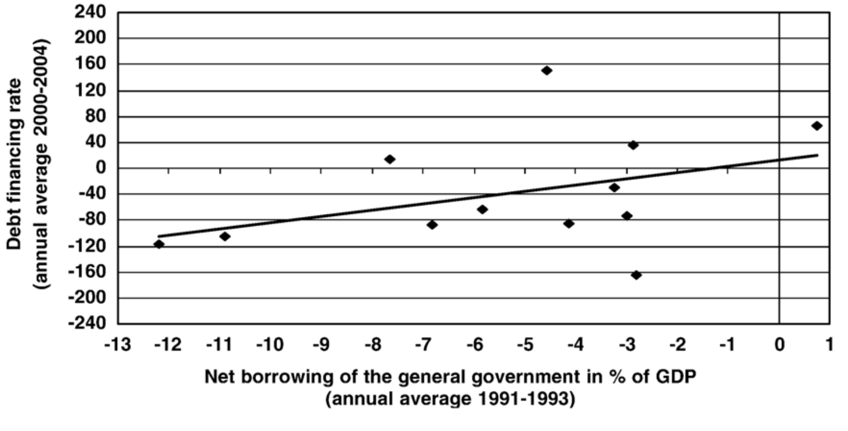

Fig. 3. Net borrowing of the general government in percentage of GDP and debt financing rate. Source: See Eurostat and own calculations.

financing engage more in public investment than others. In contrast, simple benchmarking gives the impression that countries using current financing achieve higher investment rates.

For all thirteen countries, Fig. 3 shows how net borrowing of the general government at the beginning of the period – as a percentage of GDP – is related to the debt-financing rate at the end of the period. Although this simple illustration does not enable control for further determinants, a slightly positive correlation between the two variables can be identified. Therefore countries that realized high borrowing rates in the early 1990s have a tendency to invest a lower fraction of their public borrowing at the end of the period than countries with higher fiscal discipline. More elaborate empirical analysis is presented by Tempel (1994), Heinemann (2002), and the European Commission (2003). According to Heinemann (2002), the decline of public investment in the early 1990s observed in OECD countries can be regarded as a consequence of the fast growing debt since the 1970s. Tempel (1994) also shows, for the American state and local level, that public investment decisions are not essentially but still negatively affected by the level of debt financing.

Nevertheless, Calderon et al. (2002) reported that the period of fiscal austerity experienced by most of Latin American countries in the 1980s and 1990s was characterized by a sharp contraction 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 in the 1990s. Poterba (1995) presents empirical findings for 48 American states, suggesting that tax financing of public capital projects is associated with lower levels of capital spending. With respect to our model discussed in the next section, these results should not be misinterpreted as direction of causality in the sense that funding public investment from current revenues causes a reduction in public investment. Rather, we assume that high public debt forces fiscal consolidation and in return leads to a cut in public spending mainly at the expense of public investment. It has been argued that cutting public investment is often easier politically than reducing current expenditure (see European Commission, 2003). Thus the link between consolidation and the slowdown of public investment should be interpreted as a problem of simultaneity in countries that demonstrate shortcomings in fiscal health (see Poterba and Rueben, 1999).

3. A simple growth model with public capital

Consider a growth model where the world interest rate r^* is exogenous.[10] Business cycles or any shocks are 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. 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 normalized to unity. Capital is simply non-consumed output. The production function $F(K_t,L_t,G_t)=Y_t$, with $K_t>0$, $L_t>0$ and $G_t>0$, exhibits positive diminishing marginal products with respect to each input, the Inada conditions hold, and technical progress is neglected.[11] All factors are complements in the sense that the second-order cross derivations of $F(K_t,L_t,G_t)$ are positive. Thus public capital can be considered

[10] Therefore we do not consider the controversial crowding out effect of public debt described by Modigliani (1961).

[11] Problems caused by treating public capital as a factor input like private capital and labour are discussed in Kellermann (2004b) and Romp and de Haan (2005).

as a marginal product complement to private production factors. The public capital stock only yields 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 to a degree ≤ 1 in the private factors. The production function is further assumed to be concave in K_t and G_t. These assumptions cover both cases of a publicly provided private good and of a public input of the creation-of-atmosphere type.[12]

If the production function is homogeneous to a degree of 1 in K_t, L_t, and G_t, together the public input can be interpreted as a publicly provided private good. In this case – according to Euler's theorem – total output can be decomposed into the imputed shares of private capital, public capital and labour. Since the government supplies its services free of charge, national income is not exhausted if private inputs are paid the value of their marginal products. In the following, I assume that possible factor rents are appropriated by the factor labour. Private capital is thus paid the value of its marginal product independently of whether public capital is assumed to be a publicly provided private good or a creation-of-atmosphere type good (see Gramlich, 1994).

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

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

Since firms are free to invest and produce domestically or abroad, the net of tax return on capital is the same everywhere $r=r^*$ 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 Diamond–Samuelson type overlapping-generations model. All people live for two periods, so at each point in time an old and a young generation live 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 wage income and saves the remainder $s_t = w_t - c_t^y$. In the second period of life, the individual consumes all 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 rate of return on private saving. No residence-based tax on capital income is levied. Due to the fact that we neglect any kind of risk or uncertainty in the model, domestic, foreign, private, and public claims on capital are assumed to be perfect substitutes as stores of value.

The decision problem for young people is to maximize a log utility function $u(c_t^y, c_{t+1}^o) = \ln c_t^y + \vartheta \ln c_{t+1}^o$; subject to the private budget constraint $c_t^y = w_t - t_t - c_{t+1}^o/(1+r^*)$, where t_t denotes a non-distortionary lump-sum tax that everybody must pay during the time of youth. The parameter ϑ, with $0 < \vartheta < 1$ denotes the subjective discount factor. The first-order condition for maximum

[12] Public inputs are mainly distinguished as follows (see Feehan, 1989): The creation of atmosphere – or factor-augmenting type of public capital; publicly provided private inputs, firm-augmenting public inputs that are congestible among firms and semi-public inputs congestible within industries. We focus on publicly provided private inputs or factor-augmenting public inputs.

private utility is $\frac{\partial u}{\partial c_{t+1}^{o}} / \frac{\partial u}{\partial c_{t}^{y}} = \frac{1}{1+r^{*}}$. Thus, for the marginal time preference of private households, $\left(\frac{\partial u}{\partial c_{t}^{y}} / \frac{\partial u}{\partial c_{t+1}^{o}}\right) - 1 = r^{*}$. Due to the source tax, distortions arise in the private sector, which prevents the equalization of the private marginal time preference and the marginal productivity of private capital.[13] The optimal consumption of somebody born in t while old is $c_{t+1}^{o} = \vartheta(1+r^{*})c_{t}^{y}$ so that the private optimum follows as

$$(1+\vartheta)c_{t}^{\mathrm{y}} + t_{t} = w_{t}\,. \tag{3}$$

The budget constraint of the public sector is given by

$$G_{t+1} - G_{t} + D_{t} + r^{*}B_{t} = B_{t+1} - B_{t} + K_{t}\frac{r^{*}}{(1-\tau_{t})}\tau_{t} + T_{t}. \tag{4}$$

Public consumption is neglected in the model. Thus public expenditure consists of public net investment $(G_{t+1} - G_{t})$, public depreciation D_t and debt service $r^{*}B_t$. Empirically, there are unresolved questions about how to measure depreciation of the public capital stock (see European Commission, 2003). Therefore and because it makes the model easier to handle, we treat public depreciation as exogenous.[14] B_t is the government interest bearing debt at the end of period t, which leads to debt service $r^{*}B_t$ in period $t+1$.[15] Taxes levied are the source-based capital tax where total tax collection is given by $K_t\tau_t r^{*}/(1-\tau_t)$ and the lump sum tax on young people where total tax collection is given by $t_tL_t = T_t$. In period t tax revenue plus public borrowing equals net investment $(G_{t+1} - G_{t})$, depreciation D_t and the debt service $r^{*}B_t$.

According to the golden rule, public borrowing $(B_{t+1} - B_{t})$ cannot exceed public net investment $(G_{t+1} - G_{t})$. Therefore, in each period the tax revenue must at least cover the debt service plus public capital deprecation. The tax revenue that exceeds the debt service is used to finance public investment

$$K_{t}\frac{\tau_{t}r^{*}}{(1-\tau_{t})} + T_{t} - r^{*}B_{t} - D_{t} = \theta_{t} \geq 0, \tag{5}$$

where the tax financed public investment $\theta_t = (G_{t+1} - G_t) - (B_{t+1} - B_t)$ – which equalizes public net investment minus net borrowing of the public sector – is not allowed to become negative.[16] Net investment, net borrowing and θ_t are the three instruments at the government's disposal. The lump sum tax t_t is assumed be exogenous, so that the source tax rate is given by Eq. (5).

[13] From the so-called "second-best shadow pricing approaches", discussed in the theory of optimal taxation, we know that in this case the government should use neither r^{*}, the time preference of the private household, nor the marginal productivity of private capital as a social discount rate (see Diamond, 1968; Sandmo and Drezé, 1971; Marchand and Pestieau, 1984).

[14] Pursuant to the excessive deficit procedure referred to in the appendix of Article 104 of the Treaty establishing the European Community, investment means gross fixed capital formation as defined in the European System of Integrated Economic Accounts. The implementation of the golden rule in Germany is also problematic in not taking depreciation into account. Consequently, the debt level may rise without being accompanied by a corresponding growth in assets (see Deutsche Bundesbank, 2005).

[15] 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 affects the borrowing costs of the public sector. States with strict anti-deficit fiscal conditions pay less to issue new debt. This effect reinforces the conclusion of our model in the sense that debt financing increases the opportunity costs of public investment. Nevertheless, this aspect is neglected in our model.

[16] From Eq. (4) we derive the intertemporal budget constraint $B_t = \sum_{i=0}^{T} \frac{\tau_t[Y_{t+i} - w_{t+i}L_{t+i}] + T_{t+i} - (G_{t+1+i} - G_{t+i} + D_{t+i})}{(1+r^{*})^{i}} + \left[\frac{1}{1+r^{*}}\right]^{T} B_{t+T}$. The transversality condition $\lim_{i\to\infty}(1/(1+r^{*}))^{i}B_{t+i} = 0$ implies that asymptotically public gross investment is covered by taxes independently of whether the golden rule is implemented. The transversality condition $\lim_{i\to\infty}(1/(1+r^{*}))^{i}G_{t+i} = 0$ implies that $r^{*} > n$ holds, where n denotes the natural growth rate. This condition will become important in Section 3.2.

3.1. Opportunity costs of tax and debt financing of public investment

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 seeks to maximize 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 for u_t. The government maximizes the welfare function subject to the private constraints (2) and (3), the public budget constraint and the golden rule of public sector borrowing that can be interpreted as the nonnegativity restriction $\theta_t \geq 0$. Additional constraints hold that G_1 and B_1 are given. Accordingly, the Lagrangian expression is

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

where the Lagrange multipliers μ_t, ρ_t, and δ_t are functions of t. Applying the Kuhn–Tucker conditions – see the Appendix – we find the first-order condition according to which the shadow value of θ is given by

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

The shadow value of public borrowing is

$$\mu_t \leq \frac{\dfrac{(1+\lambda)^{-t}}{c_{t+1}^y}\dfrac{1}{L_{t+1}}\left[\dfrac{\partial W_{t+1}}{\partial K_{t+1}}\right]}{\left[\dfrac{\partial W_{t+1}}{\partial K_{t+1}} - \dfrac{r^* \tau_{t+1}}{(1-\tau_{t+1})}\right]} r^* + \mu_{t+1}. \tag{8}$$

Using the derivative of the Lagrange function for G_{t+1}, we obtain the shadow benefit of the public input. At the optimum the shadow benefit of the public input equals the shadow value of a euro absorbed by the public sector, and thus the "shadow profit" becomes zero. The Kuhn–Tucker conditions allow that the optimality constraints can be expressed as

$$\begin{aligned}\left[\frac{\partial Y_{t+1}}{\partial G_{t+1}}\right] \leq (1+\lambda)(1+n)\frac{c_{t+1}^y}{c_t^y}\frac{\left[\dfrac{\partial W_t}{\partial K_t}\right]}{\left[\dfrac{\partial W_{t+1}}{\partial K_{t+1}}\right]}\frac{\left[\dfrac{(\theta_{t+1} + r^* B_{t+1} + D_{t+1} - T_{t+1})}{K_{t+1}} - \dfrac{\partial W_{t+1}}{\partial K_{t+1}}\right]}{\left[\dfrac{(\theta_t + r^* B_t + D_t - T_t)}{K_t} - \dfrac{\partial W_t}{\partial K_t}\right]} - 1 \\ + \frac{\dfrac{\partial W_{t+1}}{\partial G_{t+1}}}{\left[\dfrac{\partial W_{t+1}}{\partial K_{t+1}}\right]}\left[\frac{(\theta_{t+1} + r^* B_{t+1} + D_{t+1} - T_{t+1})}{K_{t+1}}\right]\end{aligned} \tag{9}$$

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

$$\left[\frac{\partial Y_{t+1}}{\partial G_{t+1}}\right] \leq r^* + \frac{\frac{\partial W_{t+1}}{\partial G_{t+1}}}{\frac{\partial W_{t+1}}{\partial K_{t+1}}} \left[\frac{(\theta_{t+1} + r^* B_{t+1} + D_{t+1} - T_{t+1})}{K_{t+1}}\right] \tag{10}$$

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

The left-hand side of the inequalities (9) and (10) represents the partial marginal productivity of public capital. As can be seen from the right-hand side of the inequality conditions, the social marginal opportunity costs of public investment depend on the financing instruments. Let n denote the natural growth rate, with $L_{t+1} = (1+n)L_t$. Eq. (10) shows that the opportunity costs of debt-financed public inputs include the market price of public investment r^* plus the excess burden incurred by shifting money from the private to the public sector. Although the interest rate is assumed to be constant, the debt policy has a distortionary effect on the private sector if a source-based tax is used, because public interest payments and depreciation have to be covered by tax revenue. The source-based tax on capital affects the first-order condition of the private firm and is the source of distortions. Thus, in case of debt financing, social opportunity costs are not equal to the market price of capital r^*[17]. If only a non-disturbing lump sum tax is levied, the opportunity costs of public investment shrinks because the distortionary effect of taxation vanishes. The public budget constraint becomes $T_t = \theta_t + r^* B_t + D_t$ and in case of debt financing the opportunity cost of public investment equals the interest rate r^*, as shown by Eq. (10).

What are the conclusions that can be drawn from the inequality constraints (9) and (10)? In case of an interior solution the government uses both financing instruments. Thus the shadow price of a tax-euro equals the shadow price of a debt-euro. In case of a boundary solution a benevolent government chooses the financial instrument that creates the lower shadow price whereas the other financing instrument is not used and takes a zero value. From Eqs. (7) and (8) it can be shown that debt financing of public expenditure, i.e. $B_{t+1} - B_t > 0$, will only be chosen, if

$$r^* \leq (1+n)(1+\lambda) \frac{c^y_{t+1}}{c^y_t} \frac{\left[\frac{\partial W_t}{\partial K_t}\right]\left[\frac{\partial W_{t+1}}{\partial K_{t+1}} - \frac{(\theta_{t+1} + r^* B_{t+1} + D_{t+1} - T_{t+1})}{K_{t+1}}\right]}{\left[\frac{\partial W_{t+1}}{\partial K_{t+1}}\right]\left[\frac{\partial W_t}{\partial K_t} - \frac{(\theta_t + r^* B_t + D_t - T_t)}{K_t}\right]} - 1 \tag{11}$$

holds. From Eq. (10) we see that if condition (11) holds as an inequality constraint, $\theta_t = 0$ must hold too, otherwise condition (9) is not met. Only in this case the government finances public investment by debt, because the shadow price of a debt-euro is lower than the shadow price of a tax-euro and the economy achieves the welfare maximizing steady state in period $t+1$. However, restriction (9) is violated in period $t+1$ if in the long run the government time preference is lower than the interest rate on government borrowing. For $r^* > (1+\lambda)(1+n) - 1$ restriction (9) becomes a binding constraint in period $t+1$. Under this condition, a switch from debt to tax financing is

[17] For a constant output elasticity of private capital, the income share of public capital is given by $\left(K_t \frac{r^*}{(1-\tau_t)}\right) = \left(\frac{\partial Y_t}{\partial K_t} \frac{K_t}{Y_t} Y_t\right) = \alpha Y_t$, thus the government equalizes the marginal productivity of private capital and debt-financed public capital.

welfare improving.[18] The benevolent government will not choose public debt as an instrument to finance public net investment, because the marginal social opportunity costs of tax financing are lower than the opportunity costs of debt financing. This solution holds independently of whether a distorting or a non-distorting tax is levied. In the long run $B_{t+1}-B_t=0$ must hold for $r^*>(1+\lambda)(1+n)-1$, otherwise condition (10) is violated.

This result demonstrates that a benevolent government caring about future generations will use taxes to finance public investment at least from period $t+1$ onwards. In the short run, debt financing is justified if public investments give rise to considerable growth in private consumption. This requires a corresponding undersupply of public capital initially. In period t public capital investment can cause a growth effect that raises the marginal opportunity costs of tax financed public investments. This becomes obvious if we assume that no source tax is levied, so that condition (11) can be expressed as $r^*\leq(1+n)(1+\lambda)\frac{c^y_{t+1}}{c^y_t}-1$. The right hand side represents the marginal opportunity costs of tax financed public investments. In a growing economy $(c^y_{t+1}/c^y_t)>1$. Thus if public investments enhance large enough transitory growth effects, the opportunity costs of debt financed public input can be lower than those of tax financed public inputs in the short run. However, allowing public investment to be financed by debt does not enhance public investment in the long run if $r^*>(1+\lambda)(1+n)-1$, because in the long run $(c^y_{t+1}/c^y_t)=1$.

Is the assumption that r^* – and thus the private rate of time preference – exceeds the social rate of time preference acceptable or should we instead assume the opposite?[19] There are two ways to answer this question: empirically and ethically. In the Ramsey tradition one can argue that zero is the only ethically justified value for the rate at which government discounts the utility of future generations λ. Arrow (1997) cites as opponents or at least critics of a pure time preference, Pigou, Harrod, Solow and even Koopmans, who has in fact made the basic argument for a positive discount rate λ. According to them, discounting later enjoyments in comparison with earlier ones is ethically indefensible. Although it is widely accepted that a public discount rate of zero would not be easy to define on any democratic principle, it seems fair to surmise that the discount rate should be "fairly low". If $\lambda=0$ holds in the long run, condition (11) could be reduced to $r^*<n$, so public debt financing would only be efficient if the market interest rate is below the steady state rate of economic growth. From Eq. (1) we know that the rate of return on private capital is equal to or above the interest rate. Thus debt financing is only efficient if the economy is dynamically inefficient.

From an empirical point of view, one can ask whether the social rate of time preference of the government is likely to exceed the average interest rate paid on government bonds. However, if this is the case, the question remains why governments do not borrow more even to finance public current expenditure. A social rate of time preference that is lower than the government rate of borrowing means that the shadow price of debt financing is lower than the shadow price of tax

[18] A transition period is needed to switch from tax financing to debt financing of public capital during which – under plausible circumstances – consumption of some cohorts will be lower than otherwise. The magnitude of the transition losses and the allocation of these losses to different age cohorts who live through the transition are discussed in Kellermann (2004a). In our model, voters regardless of age do not benefit from public investment programs carried out during their lifetime, because in their private decisions current generations do not care about the welfare of future generations and leave no bequest. However, Cukierman and Metzler (1986) argue that a constitutional rule should ensure that politicians act as social planners who maximize expected social welfare. In our model we therefore ask whether a social planner would finance public investment by debt.

[19] According to the so-called Mehra–Prescott puzzle, in the USA the interest rate on government bonds has been much lower than the long-run average return on equity and even lower than the average growth rate of consumption in the past (see Siegel and Thaler, 1997).

financing. In this case, not only public investment, but also public consumption, should be financed by public borrowing.[20]

3.2. Long term effects of debt financing of public investment

In the steady state the public capital stock grows at rate n, the long run growth rate of the economy. Thus the long run net public investment flows nG_t are homogeneous over time. Expressing the public budget constraint in per capita units, we have $ng=-d+nb-r^*b+kr^*\tau/(1-\tau)+t$. The steady state per capita values have no time index. With pure tax financing, public debt per capita converges to zero: $\lim_{t\to\infty}(B_t/(1+n)^{(t-1)}L_t)=0$, and the tax burden per capita imposed on the private sector is

$$kr^*\tau/(1-\tau)+t=ng+d. \tag{12}$$

If the government uses borrowing to finance public investment, the golden rule states that tax revenue covers public interest payments plus depreciation, so net investment equals net borrowing. Thus the public capital stock converges with public debt and the public budget constraint can be reduced to

$$kr^*\tau/(1-\tau)+t=r^*g+d. \tag{13}$$

Ceteris paribus, for $r^*>n$ the tax burden induced by debt financing will be greater than in case of tax financing.

However, the lower the opportunity costs of providing public investment flows, the higher public investments are. Borrowing leads to higher opportunity costs and thus to lower public investment and a lower public capital stock in the long run. If the comparison were between steady state economies, the economy that refrains from debt financing would enjoy a higher public capital stock.[21]

We discuss an example to describe the different effects of tax and debt financing on the relevant aggregates and variables. For simplicity the production function is specified as $F(K_t,L_t,G_t)=K_t^{\alpha}L_t^{\beta}G_t^{\varepsilon}$, where α, β and ε are the output elasticities, with $\alpha+\beta+\varepsilon=1$. Under this assumption public inputs can be considered as publicly provided private goods. We further assume that public capital provides rents to labour. Thus the income share of the public capital is appropriated by labour, and wage income $w_t=(1-\alpha)y_t$. The first order conditions (1), (9), (10) and the public budget constraint (4) imply that one non-trivial steady state exists for the case of tax financing as well as debt financing.[22]

[20] Note that condition (11) does not depend on the kind of expenditure the government has to finance.

[21] Based on our model, we cannot follow Modigliani et al. (1998), who argues that "in order for an expansion of public investment... it is necessary that it should be financed neither by cutting other expenditure – except for transfer payments whenever it is possible – nor by raising taxes (which at present would be practically impossible anyway). This means that the additional investments must be financed, for most of the countries, in just the same way as private investments are typically financed, namely by raising the money in the capital markets in the form of debt or equity." The reason is easy to see. Debt financed public investment puts a higher burden on the public budget than tax financed public investment, even if the growth effects induced by public investments are slight.

[22] According to Ni and Wang (1995) these steady states are locally stable.

Using condition (1), (9), and (10) together with the specified production function, the steady state value of the public per capita capital stock is

$$g_{\mathrm{TAX}} = \left(\left(\frac{\alpha(1-\tau)}{r^*}\right)^{\alpha}\left(\frac{\varepsilon(1-\tau)}{(1+\lambda)(1+n)-1}\right)^{1-\alpha}\right)^{\frac{1}{1-\alpha-\varepsilon}}$$

$$g_{\mathrm{DEBT}} = \left(\left(\frac{\alpha(1-\tau)}{r^*}\right)^{\alpha}\left(\frac{\varepsilon(1-\tau)}{r^*}\right)^{1-\alpha}\right)^{\frac{1}{1-\alpha-\varepsilon}}$$

The indices DEBT and TAX indicate debt and tax financing. The private per capita capital stock is

$$k_{\mathrm{TAX}} = \left(\left(\frac{\alpha(1-\tau)}{r^*}\right)^{1-\varepsilon}\left(\frac{\varepsilon(1-\tau)}{(1+\lambda)(1+n)-1}\right)^{\varepsilon}\right)^{\frac{1}{1-\alpha-\varepsilon}}$$

$$k_{\mathrm{DEBT}} = \left(\left(\frac{\alpha(1-\tau)}{r^*}\right)^{1-\varepsilon}\left(\frac{\varepsilon(1-\tau)}{r^*}\right)^{\varepsilon}\right)^{\frac{1}{1-\alpha-\varepsilon}}.$$

Thus per capita output is

$$y_{\mathrm{TAX}} = \left(\left(\frac{\alpha(1-\tau)}{r^*}\right)^{\alpha}\left(\frac{\varepsilon(1-\tau)}{(1+\lambda)(1+n)-1}\right)^{\varepsilon}\right)^{\frac{1}{1-\alpha-\varepsilon}}$$

$$y_{\mathrm{DEBT}} = \left(\left(\frac{\alpha(1-\tau)}{r^*}\right)^{\alpha}\left(\frac{\varepsilon(1-\tau)}{r^*}\right)^{\varepsilon}\right)^{\frac{1}{1-\alpha-\varepsilon}}.$$

If the depreciation of public capital is covered by the lump sum tax, so that $d=t$

$$\tau_{\mathrm{TAX}} = \frac{ng}{\alpha y} = \frac{n\varepsilon}{\alpha}\left(\frac{1-\tau}{(1+\lambda)(1+n)-1}\right)$$

$$\tau_{\mathrm{DEBT}} = \frac{\varepsilon}{\varepsilon+\alpha}$$

holds with respect to the source tax. If the social rate of time preference is lower than r^*, the steady state supply of public capital per capita g is lower in case of debt financing than in case of tax financing whereas the tax rate on capital income is higher. Therefore we have two negative effects on private capital formation caused by public borrowing: first, a higher tax rate τ that leads to a higher outflow of private capital, an effect that is sometimes referred to as tax induced international capital flight. Secondly, lower public capital supply leads to a weaker productivity effect to private capital and thus a lower compensation of private capital outflows (see Kellermann, 2006). As a result, the private capital stock $k_{\mathrm{DEBT}}<k_{\mathrm{TAX}}$. Since private and public capital formation is higher in case of tax financing, $y_{\mathrm{TAX}}>y_{\mathrm{DEBT}}$ and $w_{\mathrm{TAX}}>w_{\mathrm{DEBT}}$. If we assume $d=t$ does not rise disproportionately, this result also holds for the available income.

4. Conclusions

The golden rule of public sector borrowing is that government borrowing should not exceed public capital formation over the cycle. Thus, current expenditure should be covered by current receipts while recourse to debt is allowed for investment spending. In recent years the golden rule has been suggested as a way of modifying and loosening the EMU fiscal rules. It has been argued that the Stability and Growth Pact in its initial version may reduce the public sector's contribution to capital accumulation and that implementation of a more golden-rule oriented fiscal rule may prevent an investment slowdown in the public sector of EMU member countries. Following the change of the Stability and Growth Pact, exceeding the maximum value of annual government budget deficit of 3% of GDP can be justified by public investment.

Most arguments in the controversial debate of the rationality of the golden rule are in a political economic setting. It has been argued that, if the process of public decision-making produces a bias towards excessive public investment, then the adoption of the golden rule may prove counter-productive. On the other hand, if a tendency towards strategic underinvestment predominates – as proposed by Peletier et al. (1999) – then the golden rule assures a more efficient level of public investment. In normative settings the golden rule is often judged as "essentially plausible" (see Deutsche Bundesbank, 2005). In this paper however, using a normative framework, I have challenged this common viewpoint and show that debt financing of public investment does not enhance economic growth. The arguments presented in this paper add an important aspect to the debate of the golden rule. I argue that public borrowing is not an efficient instrument for financing public investment by examining how debt financing affects social welfare as well as the stock of public and private capital. Public capital is considered to increase private factor productivity and is provided by government to improve labour productivity or accommodate mobile capital. We argue under assumptions of a distortionary source-tax and a fixed interest rate in favour of debt financing. Both assumptions could be interpreted as discriminating against the instrument of tax financing. However, 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 marginal opportunity cost of public investment. This result holds at least in the medium and long term. In the short run, financing public investment by borrowing can be justified if an undersupply of public capital initially exists so that public investment gives rise to considerable transitory growth effects.

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Appendix A

This Appendix presents results derived in the text.

$$\frac{\partial \Gamma}{\partial \theta_t} = \mu_t - \rho_t \leq 0 \qquad \theta_t \geq 0; \qquad \theta_t \frac{\partial \Gamma}{\partial \theta_t} = 0 \tag{A1}$$

$$\frac{\partial \Gamma}{\partial B_{t+1}} = \mu_t - \mu_{t+1} - \rho_{t+1} r^* \leq 0 \quad [B_{t+1} - B_t] \geq 0; \qquad [B_{t+1} - B_t] \frac{\partial \Gamma}{\partial B_{t+1}} = 0 \tag{A2}$$

The golden rule of public sector borrowing states that the nonnegativity restriction $\theta_t \geq 0$ holds. Given the technology assumed and the assumption of a log utility function of the private household, the nonnegativity restrictions $K_t > 0$, $G_t > 0$, and $c_t^y > 0$ must hold, so that the Kuhn–Tucker conditions reduce to:

$$\frac{\partial \Gamma}{\partial K_t} = \rho_t \left[\frac{\partial Y_t(G_t, K_t)}{\partial K_t} - \frac{\partial W_t(G_t, K_t)}{\partial K_t} - r^* \right] + \delta_t \left[\frac{1}{L_t} \frac{\partial W_t(G_t, K_t)}{\partial K_t} \right] = 0 \tag{A3}$$

$$\rho_t = \frac{\delta_t}{L_t} \frac{\left[\frac{\partial W_t(G_t, K_t)}{\partial K_t} \right]}{\left[\frac{\partial W_t(G_t, K_t)}{\partial K_t} - \frac{(\theta_t + r^* B_t - T_t + D_t)}{K_t} \right]}$$

$$\frac{\partial \Gamma}{\partial c_t^y} = \frac{\partial \Psi}{\partial c_t^y} - \delta_t [1 + \vartheta] \qquad \frac{\partial \Psi}{\partial c_t^y} = \frac{(1+\lambda)^{1-t}(1+\vartheta)}{c_t^y} \qquad \delta_t = \frac{(1+\lambda)^{1-t}}{c_t^y} \tag{A4}$$

$$\begin{aligned} \frac{\partial \Gamma}{\partial G_{t+1}} = {} & -\mu_t + \mu_{t+1} + \rho_{t+1} \left[\frac{\partial Y_{t+1}(G_{t+1}, K_{t+1})}{\partial G_{t+1}} - \frac{\partial W_{t+1}(G_{t+1}, K_{t+1})}{\partial G_{t+1}} \right] \\ & + \delta_{t+1} \left[\frac{1}{L_{t+1}} \frac{\partial W_{t+1}(G_{t+1}, K_{t+1})}{\partial G_{t+1}} \right] \end{aligned} \tag{A5}$$

Substituting δ_t from Eq. (A4) into ρ_t from Eq. (A3) and eliminating the Lagrange parameter ρ_t in Eq. (A1), we obtain the shadow price of a tax-euro presented in Eq. (7). Substituting ρ_{t+1} into Eq. (A2), we obtain the shadow price of a debt-euro presented in Eq. (8). Using Eq. (5) $\frac{(\theta_t + r^* B_t - T_t + D_t)}{K_t}$ can be replaced by $\frac{r^* \tau_t}{(1-\tau_t)}$.

Substituting δ_{t+1} and ρ_{t+1} into Eq. (A5) we have the shadow value of public investment

$$[\mu_t - \mu_{t+1}] = \frac{(1+\lambda)^{-t}}{L_{t+1} c_{t+1}^y} \left[\frac{\frac{\partial W_{t+1}(G_{t+1}, K_{t+1})}{\partial K_{t+1}} \frac{\partial Y_{t+1}(G_{t+1}, K_{t+1})}{\partial G_{t+1}} - \frac{\partial W_{t+1}(G_{t+1}, K_{t+1})}{\partial G_{t+1}} \frac{(\theta_{t+1} + r^* B_{t+1} - T_{t+1} + D_{t+1})}{K_{t+1}}}{\frac{\partial W_{t+1}(G_{t+1}, K_{t+1})}{\partial K_{t+1}} - \frac{(\theta_{t+1} + r^* B_{t+1} - T_t + D_t)}{K_{t+1}}} \right] \tag{A6}$$

Eqs. (A6) and (7) give the optimality constraint (9). Eqs. (A6) and (8) give the optimality constraint (10). Note that Eq. (8) can be expressed as

$$\mu_t \leq r^* \sum_{i=1}^{\infty} (1+\lambda)^{1-(t+i)} \frac{1}{L_{t+i} c^{y}_{t+i}} \left[\frac{\frac{\partial W_{t+i}(G_{t+i}, K_{t+i})}{\partial K_{t+i}}}{\frac{\partial W_{t+i}(G_{t+i}, K_{t+i})}{\partial K_{t+i}} - \frac{r^* \tau_{t+i}}{(1-\tau_{t+i})}} \right] \tag{A7}$$

It becomes apparent that the burden of debt financing must not be borne by the generation born in period t where debt is accumulated but by the generations born in later periods $t+i$ for $i=1\ldots\infty$. The burden of tax financing appears fully in period t. Since public investment provides deferred benefits, the means of financing can affect intergenerational distribution. Tax financing implies a welfare loss for the generation born in period t, because this generation fully pays for investment but the benefits of the investment will increase the wage income of future generations. Nevertheless, with more or less homogeneous public investment flows, this aspect of intergenerational equity is of diminished importance.

References

Arrow, K.J., 1997. Discounting, morality, and gaming. Working paper no. 97-004, Stanford University, Staford.

Balassone, F., Franco, D., 2000. Public investment, the stability pact and the "golden rule". Fiscal Studies 21, 207–229.

Buchanan, J.M., 1967. Public Finance in Democratic Process, Fiscal Institutions and Individual Choice. University of North Carolina Press, Chapel Hill.

Buiter, W.H., 2001. Notes on 'A code for fiscal stability'. Oxford Economic Papers 53, 1–19.

Calderon, C., Easterly, W., Serven, L., 2002. Infrastructure compression and public sector solvency in Latin America. Documentos de Trabajo Banco - Central de Chile 187 (Santiago de Chile).

European Commission, 2003. Public finances in EMU — 2003. European Economy 3 (Luxembourg).

European Commission, 2005. Proposal for a council regulation amending regulation (EC) No. 1467/97 on speeding up and clarifying the implementation of the excessive deficit procedure. COM(2005) 155 final, Brussels, 20.4.2005.

Cukierman, A., Metzler, A.H., 1986. A positive theory of discretionary policy, the cost of democratic government, and the benefits of a constitution. Economic Inquiry 24, 367–388.

Deutsche Bundesbank, 2005. The changes to the stability and growth pact. Monthly Report 57 (4), 15–21.

DGB — Deutscher Gewerkschaftsbund, 2003. Mut zum Umsteuern: Für Wachstum, mehr Beschäftigung und soziale Gerechtigkeit. Hintergrundpapier für die wirtschafts-und sozialpolitische Reformagenda des Deutschen Gewerk schaftsbundes.

Diamond, P., 1968. The opportunity costs of public investment: comment. Quarterly Journal of Economics 82, 682–688.

Emmerson, C., Frayne, C., Love, S., 2003. The government's fiscal rules. Briefing Note no. 16. Institute for Fiscal Studies, London.

ESA — European System of National and Regional Accounts, 1996. European System of National and Regional Accounts (ESA 95). Eurostat, Luxembourg.

Feehan, J.P., 1989. Pareto-efficiency with three varieties of public input. Public Finance 44, 237–248.

Gramlich, E.M., 1994. Infrastructure investment: a review essay. Journal of Economic Literature 32, 1176–1196.

Heinemann, F., 2002. Factor mobility, government debt and the decline in public investment. Discussion Paper no. 02–19. Centre for European Economic Research, Mannheim.

HM Treasury, 1998. The Public Sector Balance Sheet. HM Treasury, London.

Kato, R.R., 2002. Government deficit, public investment, and public capital in the transition to an aging Japan. Journal of the Japanese and International Economics 16, 462–491.

Kellermann, K., 2004a. Finanzierungsformen und Opportunitätskosten öffentlicher Investitionen. Jahrbücher für Nationalökonomie und Statistik 224, 471–487.

Kellermann, K., 2004b. Should Mobile Capital Pay for Public Infrastructure Investment? Working Paper no. 377. Faculty of Economics and Social Sciences, University of Fribourg.

Kellermann, K., 2006. A note on intertemporal fiscal competition and redistribution. International Tax and Public Finance 13, 151–161.
Kopits, G., 2001. Fiscal rules: Useful policy framework or unnecessary ornament? Working Paper no. 01/145. IMF, Washington DC.
Kopits, G., Symansky, S., 1998. Fiscal Policy Rules. Occasional Paper no. 162. IMF, Washington DC.
Marchand, M., Pestieau, P., 1984. Discount rates and shadow prices for public investment. Journal of Public Economics 24, 153–169.
Modigliani, F., 1961. Long-run implications of alternative fiscal policies and the burden of national debt. Economic Journal 71, 730–755.
Modigliani, F., Fitoussi, J.-P., Moro, B., Snower, D., Solow, R., Steinherr, A., Labini, P.S., 1998. An economist's manifesto on unemployment in the European Union. BNL Quarterly Review 206 (September).
Moro, D., 2002. Public investment in European Union: A comparison between stability and growth pact and the United Kingdom golden rule. Rivista Internazionale di Scienze Sociali 110, 239–266.
Musgrave, R.A., 1939. The nature of budgetary balance and the case for a capital budget. American Economic Review 29, 260–271.
Ni, S., Wang, X., 1995. Balanced government budgets versus deficit finance in a growth economy. The Canadian Journal of Economics 28, 1120–1134.
Peletier, B., Dur, R., Swank, O.H., 1999. Voting on the budget deficit: comment. American Economic Review 89, 1377–1381.
Poterba, J.M., 1995. Capital budgets, borrowing rules and state capital spending. Journal of Public Economics 56, 165–187.
Poterba, J.M., Rueben, K.S., 1999. Fiscal Rules and State Borrowing Costs: Evidence From California and Other States. Public Policy Institute of California, San Francisco.
Robinson, M., 1998. Measuring compliance with the golden rule. Fiscal Studies 19, 447–462.
Romp, W., de Haan, J., 2005. Public capital and economic growth: a critical survey. European Investment Bank: EIB Papers 10, 40–73.
Sandmo, A., Drezé, J.H., 1971. Discount rates for public investment in closed and open economies. Economica 38, 395–412.
Siegel, J.J., Thaler, R.H., 1997. Anomalies: the equity premium puzzle. Journal of Economic Perspectives 11, 191–200.
Tempel, J., 1994. The debt/tax choice in the financing of state and local capital expenditure. Journal of Regional Science 34, 529–547.
Weingast, B., Kenneth, C.J., Shepsle, A., 1981. The political economy of benefits and costs: a neoclassical approach to distributive politics. Journal of Political Economy 89, 642–665.
Wyplosz, C.A., 1997. EMU: why and how it might happen. Journal of Economic Perspectives 11, 3–22.
Yakita, A., 1994. Public investment criterion with distorted capital markets in an overlapping generations economy. Journal of Macroeconomics 16, 715–728.