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Fiscal policy and public capital in interdependent economies

Martin A. van Tuijl[a,*], Robert J. de Groof[a], Ad H.J. Kolnaar[b]

[a] *Center Graduate School and Department of Economics, Tilburg University, P.O. Box 90153, 5000 LE Tilburg, Netherlands*

[b] *Department of Economics, Tilburg University, P.O. Box 90153, 5000 LE Tilburg, Netherlands*

Abstract

A two-country model is presented that has the following features: public and private capital accumulation, government debt and current account dynamics, differential saving propensities for profits and wages, imperfectly substitutable domestic and foreign commodities, a floating exchange rate, wage rigidities and flexible prices. Public capital enters into the aggregate production function. Congestion is taken into account by adjusting infrastructure for aggregate use of private factors. Numerical methods are used to trace the effects of higher public investment. Raising government investment proves to be advantageous for both regions. However, sensitivity analysis demonstrates that the long-run results in particular depend on the production-elasticity of congestion-corrected public capital.

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1. Introduction

Nowadays, world-wide fiscal policies are directed towards decreasing government outlays. Two reasons seem to be underlying this trend, namely a reduction of government debt ratios and the creation of budgetary room for tax cuts. The latter

* Corresponding author. Tel.: +31 013 4662036; fax: +31 013 4663042; e-mail: M.A.v.Tuijl@kub.nl.

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are considered to be urgent, especially in Europe, since they are believed to strengthen the supply-side of the economy. In the past, public investment was lowered, even in spite of an upward trend in total government outlays. Tanzi and Lutz (1990) provide empirical evidence that the share of government investment spending has dropped in a substantial number of OECD countries during the period 1970–1987. This may be attributed to public choice considerations (Van de Klundert, 1993). Strong constituencies to protect public investment are absent. The political value of such expenditure is relatively low, because the benefits accrue only in the long run. Therefore, the present trends in fiscal policy might be expected to lead to a decline in government spending as well as to a shift in the composition of government spending, with public investment paying toll.

However, it seems that that the tide is turning: it is widely acknowledged that infrastructure is essential for economic growth (Stern, 1992). This awareness may be attributed to the fact that the neglect of infrastructure during the last few decades has turned it worldwide into a bottle-neck (Albert, 1991).

Much work has already been done on public investment. Some of the early dynamic models in which public capital is a factor of production include Shell (1967) and Arrow and Kurz (1970). Thereafter, attention on public capital formation was virtually absent during two decades, probably as a consequence of the dormancy of the field of economic growth at the time. The recent revival of interest in public investment has been triggered by empirical evidence indicating that publicly provided inputs have a strong positive impact on the level of production (Aschauer, 1989).

It should be recognized that empirical evidence in this field should be treated with some caution because empirical research faces at least two major problems. First, there is the oft-cited criticism of reverse causation, whereby, in this case, rapid output growth and high productivity lead to increased public investment rather than the other way around. However, Easterly and Rebelo (1993) point out some indirect evidence against reverse causation. They find that only some forms of public investment, notably transport and communication, but not all, are robustly correlated with growth. Secondly, no test, in which productivity is balanced against a market measure, exists for public capital. The value of public capital, therefore, as the discounted present value of what it would earn if remunerated based on marginal productivity, is not accurately measured by time series based on cost (Aaron, 1990). Given these problems, it is hardly surprising that empirical evidence is mixed (Sturm and De Haan, 1995). Some studies find that public capital is highly efficacious (Ford and Poret, 1991; Lynde and Richmond, 1993a,b) while other studies disaffirm the effectiveness of public capital (Hulten and Schwab, 1993; Holtz-Eakin, 1994, and Holtz-Eakin and Schwartz, 1995).

Nevertheless, an extensive literature concerning public capital formation has developed. Barro (1990) presents a model in which tax revenues are used to finance government services, which increase the marginal productivity of private capital. Jones et al. (1993) find huge effects on growth and welfare in a model where government spending is a productive input in investment. Barro and Sala-I-Martin (1992) show that in the public goods model of government services lump-sum taxes

are compatible with the social optimum, whereas in the congestion model a proportionate tax rate on output may preserve this social optimum. In Glomm and Ravikumar (1994) public investment is financed by uniform taxes on capital and labour. Infrastructure may exhibit varying degrees of non-rivalry. It is shown that the optimal tax rate is independent of the degree of congestion.

The common feature of all these contributions is the closed-economy framework. However, given the above-mentioned 'global' urgency to improve the infrastructure, it seems useful, from a theoretical point of view, to trace the effects of an increase in public investment using a multi-country model. A dynamic multi-country framework is used by McKibbin and Bagnoli (1993). However, public capital is treated in an overly optimistic way. First, public capital is modelled as a 'pure' public good, being non-exclusive and non-rival. The latter implies that it is not subject to congestion. Secondly, a constant marginal product of public capital is assumed, by putting it in the production function as a Hicks-neutral productivity term. In the two-country model developed by Van de Klundert (1993), public capital is also treated as a 'pure' public good. However, there it shows a decreasing marginal product. Van de Klundert studies the difference between a tax feedback rule and a feedback rule for public investment, aimed at preventing 'runaway government debt', following a bond-financed stimulus to public consumption. Therefore, the ceteris paribus effects of a decrease in public investment can hardly be traced.

Stiglitz (1988) notes that a large part of 'core infrastructure', such as roads and highways, airports, harbours, etc. is subject to congestion. For a given quantity of aggregate services, the quantity available to an individual decreases as other users congest the facilities. Here congestion is modelled by correcting the stock of public capital for the level of production. The latter functions as a proxy for the aggregate use of private factors (Glomm and Ravikumar, 1994).

Nowadays, a high degree of mobility of financial capital seems to prevail, at least among the developed countries (Razin, 1995). Therefore, a dynamic Mundell–Fleming two-country model will serve as a 'workhorse'. Some commentators may characterize the Mundell–Fleming approach as a 'trifle old-fashioned' (Van der Ploeg, 1992). However, others still praise this framework for its good reputation in tracking the performance of the international monetary system as well as predicting the outcomes of policy (Krugman, 1995). In addition, it should be noted that the Mundell–Fleming framework is still applied to empirical policy-analysis (see, for example, Manchester and McKibbin, 1994) as well as to sophisticated theoretical work in the field of interdependence (see, for example, Minford, 1995).

In addition to congestion-corrected public capital as an input to production, and a high degree of capital mobility, the model is characterized by differential saving propensities for profits and wages, private capital accumulation, government debt and current account dynamics, imperfect substitution of domestic and foreign commodities, international factor immobility, real wage inertia that is less prominent in one country (say the United States) than in the other region (say Europe), a floating exchange rate as well as flexible prices. The reason for assuming prices to

be market-clearing is twofold. First, in the empirical MSG2-model (McKibbin and Sachs, 1991), this assumption performs fairly well in explaining reality. Secondly, raising public investment is a measure primarily aimed at improving the structural, long-term properties of the economy (Van de Klundert, 1991).

The main findings are as follows. In the short run, raising public investment yields the familiar 'Locomotive policy' (henceforth LOC) result. It proves to stimulate real national income in both regions. In the long run, again both the active and the passive countries benefit. So, once more, the indication LOC policy suits. However, if public capital is totally ineffective, the long-run result must be indicated as a 'Beggar-thyself policy' (henceforth BTS). For, in that case a drop in real national income in the active country is combined with higher real national income in the passive country. Finally, if public capital is very efficacious, the results are qualitatively compatible with the standard case. It should be noted that the outcomes are then far more favourable quantitatively.

The paper is organized as follows. In Section 2 the model, linearized around its steady-state, is presented. Expressing variables in this way is not unfamiliar (Aoki, 1981; Taylor, 1985; van Els, 1990; Kolnaar and Van Nunen, 1993; as well as Meulendijks and Schouten, 1995). In spite of the model's linearity, its complexity makes an analytical solution intractable. Therefore, a comprehensive set of simulations is carried out, which will be discussed in Section 3. Analytical models sacrifice reality, for instance by ruling out several sources of dynamics in order to keep the analysis manageable. On the other hand, the results of the simulations approach are coefficient specific. To overcome this dilemma, an extensive sensitivity analysis has been conducted (see for example, Karakitsos, 1989). The results of this sensitivity analysis can be found in Appendix B. Section 4 offers some conclusions.

2. The model

In this section we present a two-country model by focusing on the equations for the home country (say Europe). Variables for the foreign country are referred to by a superscript asterisk. Except for nominal wage formation, the two regions are identical. Exogenous variables are barred. All coefficients are defined positively.

The model is linearized around a symmetrical steady-state solution. In the reference situation, both economies follow a Solow–Swan path of steady growth, determined by the population growth rate (π) and the rate of labour-augmenting technical progress (ρ).

Most variables are expressed as percentage deviations from their steady-growth values. However, there are some exceptions to this rule. First, the interest rate (r) and the net rate of return on capital (r_n) are simply expressed as the arithmetic difference from their steady-state values. Secondly, the net foreign asset position (F), the balance of trade surplus (S_b) and the capital income account surplus (S_r) are measured as the quotient of the arithmetic difference from their steady-state value, and total output of firms in the reference situation. Finally, the tax rate on wage income (t_l) is expressed as a percentage of private sector wage income.

2.1. Supply side

Private capital accumulation (Δk) is described by

$$\Delta k = \frac{\gamma_i}{\kappa(1 + \pi + \rho)}(i_{-1} - k_{-1}), \tag{1–2}$$

where i denotes gross private capital investment, γ_i refers to the ratio of gross private capital investment to output of firms, while κ indicates the private capital–output ratio. On the reference path of steady growth the Harrod–Domar condition is satisfied, implying $\gamma_i/\kappa = \pi + \rho + \delta$, where δ denotes the depreciation rate of private capital.[1]

Output follows from a constant elasticity of substitution (CES) production function with constant returns to private factors:

$$y = \varepsilon_g(k_g - y) + \lambda_l l + (1 - \lambda_l)k, \quad 0 \leq \varepsilon_g < 1, \tag{3)–(4}$$

where y denotes output of firms, l stands for employment, k_g denotes the stock of public capital, while λ_l and $1 - \lambda_l$ indicate the 'direct production elasticities of labour and private capital' respectively. ε_g denotes the elasticity of production with respect to the congestion-corrected stock of infrastructure.[2]

Public capital accumulation is analogous to private capital accumulation:

$$\Delta k_g = \frac{\gamma_{i_g}}{\kappa_g(1 + \pi + \rho)}(i_{g_{-1}} - k_{g_{-1}}), \tag{5)–(6}$$

where i_g denotes the volume of government investment, γ_{ig} refers to the ratio of public investment to output of firms, while κ_g represents the public capital–output ratio. Correspondingly, steady growth requires that $\gamma_{i_g}/\kappa_g = \pi + \rho + \delta_g$, where δ_g stands for the depreciation rate of public capital.

2.2. Labour market

Profit-maximizing firms equate the marginal product of labour and the real producers' wage ($w - p_y$), given the stocks of private and public capital at each point in time. This yields the following relation for labour demand by firms:

$$l = y - \varphi_{kl}(w - p_y). \tag{7)–(8}$$

Here w denotes the nominal wage, while p_y stands for the producers' price level. The symbol φ_{kl} denotes the elasticity of factor substitution.

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[1] The derivation of Eqs. (1)–(2) is thoroughly demonstrated in Van de Klundert (1982).

[2] As indicated above, the parameter ε_g lies between zero and unity. This reflects the decreasing marginal productivity of congestion-corrected infrastructure. Furthermore, it should be noted that $1 - \lambda_l < 1$, which implies the absence of endogenous growth.

Labour is immobile across regions. According to empirical evidence, nominal wages in the United States adapt more gradually to the development of both the consumer price index and labour productivity than nominal wages in Europe (see Van der Ploeg, 1988). Meanwhile, the existence of an error-correction mechanism in the wage relation, ensuring that wages return to their long-run equilibrium value, is not rejected (Attenasio et al., 1987). Here, it is assumed that a stylized version of this mechanism applies. Adjustment of wages to the labour market situation is assumed to be sluggish in both regions. However, wage rigidities, prohibitive for labour market equilibrium in the short and medium run, are stronger in Europe than in the United States. In the long run, the Phillips mechanism restores full employment in both regions.

Ignoring forward shifting of taxes into wages as well as possible hysteresis effects, these characteristics imply

$$\Delta w = (1 - \varepsilon_{w_{px}})\Delta w_{-1} + \varepsilon_{w_{px}}\Delta p_x + \varepsilon_{w_{px}}(\Delta y - \Delta l) + \varepsilon_{w_{lm}} l - \varepsilon_{w_{lm}}(1 - \varepsilon_{w_{px}}) l_{-1}, \tag{9)–(10}$$

where p_x refers to the price of consumer expenditure. $\varepsilon_{w_{px}}$ denotes the short-run elasticity of wages with respect to both the consumer price index and labour productivity, while $\varepsilon_{w_{lm}}$ refers to the Phillips coefficient.

2.3. Prices

The price of expenditure is the arithmetic weighted average of the producers' price level and the price of imports, expressed in home currency. Hence,

$$p_x = (1 - \gamma_{exim})p_y + \gamma_{exim}(p_y^* + e), \tag{11)–(12}$$

where γ_{exim} is the ratio of exports (and imports) to gross value added of firms, while e stands for the nominal exchange rate.

By definition, the terms of trade (P) equals the difference between the producers' price level and the price of expenditure:

$$P \equiv p_y - p_x. \tag{13)–(14}$$

2.4. Income distribution

By definition, the wage share of firms (w_y) equals

$$w_y = l + w - y - p_y. \tag{15)–(16}$$

The net rate of return on capital (r_n) equals the ratio of net profits to the capital stock. Net profits are equal to the after-tax difference between real gross value added of firms and the sum of the real wage bill and capital depreciation. Thus,

$$\frac{r_n}{\bar{r}+\psi} = \frac{y + p_y - p_x - \lambda(l + w - p_x) - (1 - \lambda_l)k}{1 - \lambda_l - \delta\kappa}. \qquad (17)–(18)$$

The denominator of Eqs. (17)–(18) reflects the fact that the equilibrium net rate of return of capital ($\bar{r}_n$) equals the rate at which governments borrow in the capital market ($\bar{r}$) on the reference path plus the risk premium (ψ). This risk premium drives a wedge between the rate at which firms can borrow in the capital markets and the rate at which governments borrow. For simplicity, this risk premium is assumed to be constant (cf. McKibbin and Sachs, 1991).

Real disposable income per worker (w_d) is equal to

$$w_d = w - p_x - t_l. \qquad (19)–(20)$$

On the reference path, taxes on the wages of workers in the market sector exactly match net public sector salaries and social benefits. The ratio of government-dependent income-earners to workers in the market sector then remains constant, both growing at a rate π. The government does not discretionarily change the growth rate of civil servants. Furthermore, civil servants' salaries and social benefits are perfectly linked to the wages of workers in the market sector. Thus, only a change in employment in the market sector necessitates an adjustment of the tax rate on wages because it alters both the tax base and the amount to be paid to social beneficiaries.

Moreover, it is assumed that the government uses the tax rate on wages as an instrument to keep the government debt ratio within limits. Therefore, it is assumed that the tax rate on wages and transfers responds to the ratio of government interest payments to the gross value-added of firms (cf. Mc Kibbin and Sachs, 1991). So,

$$t_l = -l + t_s, \qquad (21)–(22)$$

where

$$t_s = \varepsilon_{t_{r_D}}\left[\frac{\bar{r}\gamma_{d_y}}{\lambda_l}(D - y - p_y) + \frac{\gamma_{d_y}}{\lambda_l}r\right].$$

Here t_s denotes the shift term in wage–taxes, D represents the government debt, $\varepsilon_{t_{r_D}}$ refers to the elasticity of the wage–tax rate with respect to government interest payments, while γ_{d_y} indicates the government debt ratio.

2.5. *Financial markets*

The money supply (M_s) always equals the product of the constant monetary base multiplier and the exogenous amount of base money. The supply of base money exclusively originates from loans by the Central Bank to commercial banks. Needless to say, the monetary authorities have full control over the supply of money

$$M_s = \underline{M}_s. \qquad (23)–(24)$$

Transactions demand for money moves in line with nominal gross value added; speculative money demand negatively depends on the nominal rate of interest. Assuming expectations to be static implies the equality of the nominal and the real interest rates. Thus, the following relationship for money demand results:

$$M_d = \varepsilon_{m_y}(y + p_y) - \frac{\varepsilon_{m_r}}{\bar{r}} r, \qquad (25)–(26)$$

where r stands for the real interest rate, ε_{m_y} indicates the income-elasticity of money demand, while ε_{m_r} refers to the interest-elasticity of money demand. It should be noted that the assumption of steady growth imposes the value of unity on the parameter ε_{m_y}.

Money market equilibrium implies

$$M_d = M_s. \qquad (27)–(28)$$

As mentioned before, capital mobility between developed countries is supposed to be high (cf. Razin, 1995). Thus, the domestic interest rate equals the foreign interest rate plus the expected rate of depreciation plus a factor measuring the risk premium on domestic assets for foreign investors. Following Hamada (1969) and Van Ewijk (1991), the inter-country risk premium is assumed to be negatively related to the net foreign asset position (F). Under static expectations, the following relationship results:

$$r = r^* - \varepsilon_{rdif_F} F, \qquad (29)$$

where the parameter ε_{rdif_F} denotes the sensitivity of the interest rate differential with respect to the net foreign asset position.

2.6. *Aggregate demand*

Nominal aggregate demand consists of five components: private consumption, private capital investment, material government consumption, public investment and net exports. As stated before, the producers' price level clears the goods market. Hence, we may write

$$\begin{aligned} y + p_y = {} & \gamma_{c_p}(c_p + p_x) + \gamma_i(i + p_x) + \gamma_{c_g}(c_g + p_x) \\ & + \gamma_{i_g}(i_g + p_x) + \gamma_{exim}(ex + p_y - im - p_y^* - e), \end{aligned}$$

where c_p, c_g, i_g, ex and im denote the volumes of private consumption, material government consumption, public investment, exports and imports, respectively. The symbols γ_{c_p} and γ_{c_g} refer to the ratios of private and material government consumption, respectively, to the gross value-added of firms. Given Eqs. (11)–(12) and balance of trade equilibrium in the reference situation, so that γ_{c_p}, γ_i, γ_{c_g} and γ_{i_g} add up to unity, the above relationship boils down to

$$y = \gamma_{c_p} c_p + \gamma_i i + \gamma_{c_g} c_g + \gamma_{i_g} i_g + \gamma_{exim}(ex - im). \quad (30)-(31)$$

The purchasing power, which a region derives from its productive efforts, is measured by real gross value-added of firms in terms of the expenditure basket (y_x):

$$y_x = y + p_y - p_x. \quad (32)-(33)$$

Real national income (y_d) equals the sum of real gross value-added and the capital income account surplus (S_r):

$$y_d = y_x + \overline{r_{av}} F, \quad (34)-(35)$$

where $\overline{r_{av}}$ is the average rate of return on private wealth.

Differential saving propensities are assumed for profits and wages. Evidently, the propensity to save over wage and transfer income is smaller than the propensity to save over profits and interest income. Van Ewijk (1991) clearly demonstrates that mainstream microfounded life-cycle models do not conflict with differential saving. On the contrary, these models may even give a justification for it if liquidity constraints and intergenerational transfers, gifts and bequests are taken into account. To avoid the well-known Pasinetti critique, it is even assumed that the propensity to save over wage and transfer income is zero. Thus, private consumption can be explained as follows (analogous to Meulendijks and Schouten, 1995):

$$c_p = \frac{\lambda_l}{\gamma_{c_p}}(l + w - p_x - t_s) + \frac{(1 - \sigma_r)}{\gamma_{c_p}}\left[\kappa r_n\left(k + \frac{r_n}{\bar{r} + \psi}\right) + \bar{r}\gamma_{d_y}\left(\frac{r}{\bar{r}} + D\right) + \overline{r_{av}} F\right]. \quad (36)-(37)$$

The desired stock of private capital (k_d) follows from the equality of the interest rate at which firms can borrow on the capital market ($r + \psi$), and the net after-tax marginal product of capital ($[1 - \tau_r][MPK - \delta]$, where τ_r is the profit tax rate). Therefore, the relationship for the desired stock of private capital equipment can be written as

$$k_d = y - \frac{\phi_{kl}}{\frac{\bar{r} + \psi}{(1 - \tau_r)} + \delta} r. \quad (38)-(39)$$

On the reference path, private capital investment equals the gross natural growth rate ($\pi + \rho + \delta$) times the capital stock. Entrepreneurs only gradually adapt the actual capital stock to the desired capital stock in the case of a deviation from the steady-growth path. Therefore,

$$i = k + \frac{\varepsilon_{i_{k_d}}}{(\pi + \rho + \delta)}(k_d - k), \qquad (40)\text{–}(41)$$

where $\varepsilon_{i_{k_d}}$ denotes the acceleration coefficient.

Public consumption is supposed to move in line with the gross value-added of firms:

$$c_g = y + p_y - p_x. \qquad (42)\text{–}(43)$$

An identical assumption is made concerning public investment:

$$i_g = y + p_y - p_x + \underline{i}_g. \qquad (44)\text{–}(45)$$

The exogenous term ($\underline{i}_g$) indicates that public investment may be used as a policy variable.

In a two-country setting one country's exports (ex) necessarily equal the other country's imports (im^*):

$$ex = im^*. \qquad (46)\text{–}(47)$$

In the reference situation, imports move in proportion with the output of firms. Moreover, home and foreign produced goods are assumed to be imperfect substitutes. Thus, we follow the Armington tradition rather than assuming the Law of One Price to be valid. Consequently, a change in competitiveness, reflected by a mutation of the real exchange rate ($p_y^* + e - p_y$), affects imports:

$$im = y - \varepsilon_{\text{imp}}(p_y^* + e - p_y). \qquad (48)\text{–}(49)$$

The parameter ε_{imp} indicates the sensitivity of imports with respect to competitiveness.

2.7. Government budget and current account dynamics

The way of financing civil servants' salaries and social benefits, described above, entails that these outlays do not affect the budget deficit. Taxes on wages also respond to any change in the ratio of government interest payments to the gross value-added of firms. Monetary financing of the budget deficit is excluded by assumption. The government finances its deficit, government expenditure plus interest payments insofar as they are not compensated by wage-tax revenues, minus profit-tax revenues, by the issuance of new debt. Hence, the government budget identity reads

$$\begin{aligned}\gamma_{d_y}(1 + \pi + \rho)D_{+1} = {} & \gamma_{d_y}(1 + \bar{r})D + \gamma_{d_y}r \\ & - \lambda_l t_s - \tau_r\left[y + p_y - \lambda_l(l + p_l) - \delta\kappa(k + p_x)\right] \\ & + \gamma_{c_g}(c_g + p_x) + \gamma_{i_g}(i_g + p_x). \qquad (50)\text{–}(51)\end{aligned}$$

In the reference situation the government budget deficit equals the equilibrium government debt ratio times the natural growth rate ($g_n = \pi + \rho$). The primary or fiscal deficit is equal to the equilibrium government debt ratio times the (positive) growth/bond rate differential.[3]

The development of the net foreign asset position depends on the current account surplus. The latter consists of the balance of trade surplus (S_b) and the surplus on the capital income account (S_r). Thus,

$$S_b = \gamma_{exim}(ex + p_y - im - p_y^* - e), \tag{52}$$

$$S_r = \overline{r}_{av}F, \tag{53}$$

$$(1 + g_n)F_{+1} = F + S_b + S_r. \tag{54}$$

Table 1
European fiscal expansion on public investment (i_{g1} = 29.4118, 1% of output of firms)

Period	1	5	10	∞
Europe				
Production (y)	0.66	1.72	2.99	6.54
Real gross value-added (y_x)	1.03	1.72	2.75	5.36
Real national income (y_d)	1.03	1.64	2.57	4.83
Employment (l)	1.31	0.93	0.95	0
Private capital stock (k)	0	0.10	0.37	2.23
Public capital stock (k_g)	0	7.34	14.35	34.77
Government debt (D)	0	4.20	8.52	24.92
Private consumption (c_p)	0.42	1.09	2.16	4.51
Gross capital investment (i)	0.22	0.42	1.08	2.23
Trade balance (S_b)	−0.40	−0.29	−0.23	0.26
Capital income account (S_r)	0	−0.08	−0.18	−0.53
Terms of trade (P)	0.38	−0.00	−0.24	−1.18
Wage share (w_y)	−0.66	0.79	2.04	6.53
Interest rate (r)	0.18	0.52	0.76	1.72
Net foreign debt ($-F$)	0	1.36	2.97	8.81
United States				
Production (y^*)	0.49	−0.25	−0.13	0.46
Real gross value-added (y_x^*)	0.11	−0.25	0.11	1.63
Real national income (y_d^*)	0.11	−0.17	0.29	2.16
Employment (l^*)	0.97	−0.37	0.05	0
Private capital stock (k^*)	0	−0.19	−0.43	0.55
Private consumption (c_p^*)	−0.47	−0.48	−0.02	2.37
Gross capital investment (i^*)	0.05	−0.88	−0.55	0.55
Wage share (w_y^*)	−0.49	0.11	−0.18	0.46
Interest rate (r^*)	0.18	0.25	0.17	−0.04

[3] Nevertheless, the economy is dynamically efficient, as the rate of capital return exceeds the growth rate (r_n = 0.072 versus g_n = 0.03).

The model consists of 54 equations and 54 endogenous variables, namely c_g, c_p, D, ex, i, i_g, im, k, k_d, k_{inf}, l, M_d, M_s, P, p_x, p_y, r, r_n, t_l, w, w_d, w_y, y, y_d and y_x for both countries as well as e, F, S_b and S_r. The model contains five predetermined state variables, namely k and D for both regions, as well as F.

3. Stimulating public investment: Two numerical exercises

In this section the (spill-over) effects of an increase in public investment, the size of 1% of gross value-added of firms, will be studied. This will be done by discussing some policy simulations. The computations have been carried out with the PSREM package developed by Van der Ploeg and Markink (1991). Table 1 shows the short-, medium- and long-term (spill-over) effects if Europe were to take the initiative and raise public investment. There a moderate value of the production elasticity of congestion-corrected infrastructure is assumed ($\varepsilon_g = 0.2$). Table 2 demonstrates these effects in two extreme cases. First, the assumption is made that congestion-corrected public capital is completely ineffective. Secondly, public capital, even if

Table 2
European fiscal expansion on public investment ($i_{g1} = 29.4118$) ($\varepsilon_g = 0/0.4$)

Period	1	5	10	∞
Europe				
y	0.94/0.50	−0.40/2.97	−0.53/5.41	−0.21/12.82
y_x	1.31/0.89	−0.27/2.89	−0.49/4.98	−0.20/10.63
y_d	1.31/0.89	−0.34/2.80	−0.58/4.75	−0.24/9.69
l	1.57/1.18	−0.55/1.81	−0.41/1.97	0/0
k	0/0	−0.17/0.25	−0.71/1.05	−0.54/4.83
k_g	0/0	7.17/7.44	13.48/14.91	29.21/40.04
D	0/0	4.31/4.15	8.12/8.73	13.23/35.79
c_p	0.46/0.27	−1.37/2.44	−1.30/4.83	−0.53/10.34
i	0.21/0.08	−0.83/1.48	0.02/2.76	−0.00/4.83
S_b	−0.41/−0.40	−0.13/−0.39	0.04/−0.41	0.02/0.47
S_r	0/0	−0.07/−0.09	−0.10/−0.23	−0.04/−0.95
P	0.37/0.38	0.13/−0.08	0.04/−0.42	0.01/−2.19
w_y	−0.63/−0.67	0.15/1.15	−0.12/3.43	−0.21/12.82
r	0.19/0.17	0.39/0.60	0.31/1.06	0.13/3.20
$-F$	0/0	1.12/1.50	1.61/3.82	0.63/15.76
United States				
y^*	0.68/0.38	−0.40/−0.16	−0.02/−0.13	0.00/1.38
y_x^*	0.32/−0.00	−0.27/−0.08	−0.06/0.29	−0.01/3.57
y_d^*	0.32/−0.00	−0.34/0.01	0.04/0.52	0.02/4.52
l^*	1.14/0.88	−0.58/−0.24	0.17/0.02	0/0
k^*	0/0	−0.20/−0.20	−0.30/−0.51	−0.00/1.27
c_p^*	−0.25/−0.59	−0.67/−0.38	−0.02/0.06	0.01/5.01
i^*	0.21/−0.04	−0.83/−0.91	0.02/−0.87	−0.00/1.27
w_y^*	−0.46/−0.50	0.15/0.07	−0.19/−0.16	−0.00/1.38
r^*	0.19/0.17	0.16/0.30	−0.01/0.30	0.00/0.05

adjusted for congestion, is assumed to be highly efficacious, in the spirit of the empirical work of Aschauer (1989).

In describing the (spill-over) effects of higher public investment, we focus on real national income (y_d), indicating a region's spending power. However, output (y) and employment of the market sector (l) deserve attention as well. The policy variants are characterized by 'LOC' 'Beggar-Thy-Neighbour' policy (henceforth BTN), 'BTS' and 'Backward Locomotive' (henceforth BLOC), respectively.

In the short run ($t = 1$), a European fiscal expansion (Table 1) turns out to be an LOC policy, stimulating real national income (y_d) in both countries. Private consumption rises, mainly owing to a wage-tax cut, following from increased employment. Investment by firms increases moderately as the output-induced rise in the marginal product of capital slightly dominates the increase in the real interest rate. The latter stems from a rise in money demand, driven by both the increase of output (y) and a higher producers' price level. Meanwhile, European net exports are crowded out. The stimulus to aggregate demand forces up the terms of trade. The deterioration of competitiveness, combined with the positive interregional output-differential, underlie the decrease of net exports.

The improvement in the terms of trade also contributes to the fall in real labour costs. The price of expenditure now remains behind the producers' price level. Nominal wages in Europe follow the price of (consumer) expenditure to a considerable extent. The resulting decrease in real producers' wages stimulates employment (l) and, therefore, production capacity (y). Thus, a part of the incremental aggregate demand is satisfied. Evidently, real gross value added (y_x) in Europe rises considerably, since both components, production as well as the terms of trade, increase.

U.S. net exports are boosted. However, domestic expenditure decreases, following the drop in private consumption. The fall in private consumption results from the fall in real disposable income per worker. The decrease in workers' purchasing power mainly stems from the fact that the nominal wage only partly follows the consumer price index. The price of consumption rises strongly as a result of more costly imports from Europe. The rise in the consumer price index even dominates the wage-tax cut, resulting from higher employment. The decrease of domestic expenditure hampers the rise in total aggregate demand, which keeps upward pressure on the producers' price level relatively low. Therefore, the fall in real labour costs is also modest. So, employment (l^*) and output (y^*) rise, but less strongly than in Europe. However, output growth dominates the losses in the terms of trade, so that U.S. real gross value-added (y_x^*) increases. In the short run, the net foreign asset position naturally equals zero, so that the capital income account is in balance. Therefore, the LOC result holds for real national income (y_d) as well as for real gross value-added.

In the fifth period ($t = 5$), which gives information about medium-term developments, the qualification BTN policy is correct. The increase in the European stock of public capital, even if corrected for congestion, then dominates the picture. The growth of European infrastructure is mainly responsible for the fact that production capacity (y) has risen further above its reference level. The stock of private

capital is only slightly above its steady-growth level because private investment has been hampered by a higher interest rate. Employment (l) has fallen compared with the short run. This must be ascribed to the rise in real labour costs. The latter follows from both the working of the Phillips mechanism and the decline in the terms of trade.

European real gross value added (y_x) exceeds its steady-growth level more strongly than in the impact period, despite the fact that the terms of trade have dropped slightly below their reference value. The latter is a result of domestic expenditure remaining behind production possibilities. The private investment ratio is considerably below its reference value because of a higher real rate of interest. A wage-tax increase, aimed at keeping the government debt ratio within reasonable bounds, also keeps the private consumption ratio below its steady-growth value. So, maintaining goods market equilibrium requires net exports to rise, as compared with the short run. Meanwhile, European net exports are negatively affected by the positive interregional output differential. Consequently, a substantial improvement in competitiveness is necessary. Evidently, this implies a considerable fall in the terms of trade.

U.S. production capacity (y^*) has dropped severely as compared with the short run. In period 5, it is even below its reference level. This is a result of both a shrunk capital stock, resulting from the crowding-out of private investment in previous periods, and a fall in employment. The latter primarily results from the rise in the wage share. Private consumption has dropped only slightly, which implies an increase in the private consumption ratio. This makes some reduction in net exports inevitable, despite strong crowding-out of private investment. Meanwhile, U.S. net exports are favoured by the negative interregional output differential. Therefore, U.S. competitiveness must deteriorate compared with the first period. Consequently, the U.S. terms of trade now even exceed their reference value, albeit narrowly. U.S. real gross value-added of firms (y_x^*) is below its steady-growth level, since the decrease in output dominates the terms of trade improvement.

Europe faces an unfavourable net foreign asset position, resulting from uninterrupted current-account deficits during preceding periods. However, the adverse state of the capital income account is clearly dominated by higher real gross value-added. So, European real national income (y_d) exceeds its reference value. The U.S. capital income account surplus does not fully compensate for lower real gross value-added. Thus, U.S. real national income (y_d^*) is below its steady-growth level.

In the tenth period ($t = 10$), which also sheds some light on medium-term developments, LOC policy returns as the correct label. European output (y) has risen farther above its reference level. Evidently, this is mainly owing to the growth of congestion-corrected public capital. The stock of private capital has increased only moderately, while employment has hardly risen at all. Sluggish growth of the private capital stock is due to a higher real interest rate, still hampering investment. The tiny increase in employment is due to a higher wage share, which counterbalances the positive effects of higher output. The rise in the wage share

stems from both the working of the Phillips mechanism and losses in the terms of trade. The rise in domestic expenditure now lags behind the increase in production capacity. In addition to the higher interest rate depressing the private investment ratio, a government debt-induced rise in the wage-tax rate keeps down the private consumption ratio. Hence, maintaining goods market equilibrium requires a rise in net exports as compared with previous periods. A deterioration in the terms of trade forms the mirror-image of the necessary improvement of competitiveness. Nevertheless, strong output growth makes European real gross value-added (y_x) exceed its steady-state value by far. The same is true for real national income in Europe (y_d), in spite of an increased capital income account deficit, due to uninterrupted net foreign debt accumulation.

U.S. output (y^*) has risen compared with period 5. However, it is still somewhat below its steady-growth level. The capital stock increasingly suffers from crowding-out of private investment. However, wage moderation has been strong enough to raise employment above its equilibrium level. Real gross value added (y_x^*) is higher than output owing to the above-mentioned gains in the terms of trade. It has even risen above its steady-growth level. This holds all the more so for real national income (y_d^*), owing to an increased capital income account surplus.

In the long run ($t \to \infty$) the indication LOC policy suits, just as in the impact period. Europe now fully reaps the fruits of raising public investment. Congestion-corrected public capital is considerably above its reference level. The resulting rise in production capacity (y) creates considerable room for crowding-in of private investment. Therefore the private capital stock also exceeds its reference level by far which also increases production capacity. Domestic expenditure remains behind potential output. The reason is twofold. First, private consumption is hampered by higher taxes, in response to an increased government interest payments ratio. Secondly, a higher interest rate, mainly stemming from a risk premium induced by an unfavourable net foreign asset position, keeps down the investment ratio. Thus, higher net exports are necessary to prevent excess supply in the goods markets. Inevitably, the terms of trade are far less favourable than in the reference situation. On balance, however, European real gross value added of firms (y_x) substantially exceeds its reference level.

In the United States long-run production capacity (y^*) is higher than in the reference situation, too. The increase in the public capital stock, resulting from endogenously higher public investment, makes the most important contribution. The stock of private capital exceeds its reference level as well. Private investment is stimulated by the lower rate of interest. The build-up of a net foreign asset position implies a favourable inter-country risk premium. Moreover, it entails a U.S. capital income account surplus. So, the United States can afford to have a trade balance deficit. Thus, the crowding-out of net exports is not harmful. Consequently, the U.S. economy can permit itself a deterioration of its competitive position. Evidently, this entails gains in the terms of trade. The gains in the terms of trade, combined with the rise in the wage share, cause private consumption to exceed its reference level. Higher U.S. output combined with improved terms of trade imply that a U.S. real gross value-added (y_x^*) is above its reference value.

In the new steady state, Europe's capital income account shows a considerable deficit. Of course, Europe's markedly higher real gross value-added dominates this deficit on the capital income account. So, real national income (y_d) is substantially higher than in the reference situation. Of course, U.S. real national income (y_d^*) exceeds its steady-growth level, since both components do.

Table 2 contains the results of the two extreme cases ($\varepsilon_g = 0$ and $\varepsilon_g = 0.4$) mentioned above. Here, we only discuss the differences between the simulation results of these two 'borderline' cases and the results of the standard case.

Let us first look at the case in which the congestion-corrected stock of public capital leaves output unaffected ($\varepsilon_g = 0$). On impact, output (y), employment (l), etc. in both regions are then higher than in the standard case. This is owing to the fact that congestion effects with respect to the existing stock of infrastructure are now absent as well. In the medium run, the BTN result of the standard case now changes into a BLOC outcome. The initiating region, Europe, does not benefit at all from increased expenditure on infrastructure. On the contrary, higher government expenditure forces up the real interest rate, both directly and indirectly. Increased government spending has led to uninterrupted current-account deficits, causing accumulation of net foreign debt. This drives up the inter-country risk premium. The higher interest rate keeps down private investment and, with a lag, the stock of private capital. As a result, from period 3 onward European production capacity (y) is below its steady-growth value. In its track, the same is true for real gross value-added (y_x) and real national income (y_d).

In the tenth period, BTS turns out to be the adequate characterisation. In Europe, production capacity (y), real gross value added (y_x) and real national income (y_d) fall short of their reference values, which is primarily caused by crowding-out of private investment. The U.S. surplus on the capital income account is solely responsible for the fact that real national income (y_d^*) there is somewhat higher than in the reference situation.

In the long run, BTS still turns out to be the correct qualification in this case. It should be noted that the unfavourable results for Europe are small compared with the medium run. This must be attributed to wage moderation, induced by the working of the Phillips mechanism, which restores labour market equilibrium. The resulting increase in employment dampens the decrease in production capacity. It should be noted that in the United States the results are almost negligible.

Finally, let us consider the case in which the effects of an expansion of the congestion-corrected stock of public capital are quite strong ($\varepsilon_g = 0.4$). In the short run, the increase of production (y) in both regions is then lower than in the standard case. This must be ascribed to the fact that congestion with respect to existing infrastructure plays a prominent role. Europe faces a strong impetus to aggregate demand, which forces up its terms of trade strongly. This inevitably entails severe losses in the U.S. terms of trade. The latter even dominate feeble U.S. output growth, leading to a decrease in U.S. real gross value-added (y_x^*). The same holds for U.S. real national income (y_d^*), since short-term net foreign asset positions are fixed. Therefore, in the short run the qualification BTN policy is now appropriate.

In the medium run, European output (y) increases exuberantly, fostered by the growth of highly productive public capital. This explains why the marginal productivity of capital then lies above a risen real interest rate. As a result, private investment exceeds its reference level by far. Evidently, this is also true for the private capital stock. Despite higher private investment, however, domestic expenditure remains behind production capacity. Higher taxes on wages, induced by the higher public debt ratio, dampen the rise in private consumption. So, net exports have to increase, as compared with the impact period, in order to prevent excess supply in the goods markets. Meanwhile, European net exports are negatively affected by a substantial positive output differential. Thus, an impressive improvement in competitiveness is required, which implies considerable losses in the terms of trade. The terms of trade now drop below their reference value as early as the fourth period.

Looking at real national income (y_d), an LOC policy is now the proper qualification from the fifth period onward. The United States now benefits from more favourable terms of trade as well as a higher surplus on the capital income account than in the standard case. The more favourable U.S. terms of trade follow from the intensified necessity of Europe to improve its competitiveness. This is necessary to stimulate net exports, so that an excess supply in the goods markets is averted, notwithstanding strongly increased production capacity. Stronger European net foreign debt accumulation underlies the higher U.S. capital income account surplus.

Evidently, in the new steady state the qualification LOC policy also applies. It should be noted that the results are now quantitatively far more impressive than in the standard case.

4. Summary and conclusions

In this paper the effects and spill-over effects of once-and-for-all increases in public investment are examined. In time, higher public investment leads to a rise in the stock of public capital. Thereby, congestion is taken into account, so that multifactor productivity depends positively on the ratio of public capital to output. These (spill-over) effects are primarily measured in terms of real national income (y_d), the sum of real gross value-added of firms (y_x) and the surplus on the capital income account (S_r). Evidently, attention has also been paid to output (y) and employment (l) of the private sector.

In the standard case ($\varepsilon_g = 0.2$), in the short run ($t = 1$) raising public investment particularly takes on the demand side of the economy. Output (y) rises in both countries. This is compatible with the standard results in Mundell–Fleming models with a certain degree of real wage inertia, provided that a higher interest rate has only small negative effects on aggregate demand (Van der Ploeg, 1988). The positive effects of higher output in the active region on the passive region's exports then dominate the negative effects of financial crowding-out. Here the interest rate

appears in the consumption function even with a positive sign, stemming from consumption of rentiers.

The terms of trade of the active country improve, which also contributes to the rise in real gross value-added (y_x). Evidently, the passive country incurs losses in its terms of trade. However, on balance, the passive country's real gross value-added (y_x^*) increases as well. The role of the terms of trade is only a minor one owing to the low ratio of exports and imports to output. In the short run, net foreign asset positions are fixed. Consequently, the capital income account surpluses equal zero. Therefore, the results with respect to real national income (y_d) equal those with respect to real gross value-added.

In the medium run ($t = 5$), the supply effects of higher public investment play a prominent role. In the initiating country, multifactor productivity is well above its reference level. This is the dominant factor underlying higher output there. Higher production (y) is the main cause of the increase in both real gross value added (y_x) and real national income (y_d). In the passive country, however, real national income (y_d^*) falls short of its reference level, despite favourable terms of trade and a capital income account surplus. The latter follows from a favourable net foreign asset position, owing to persistent balance of trade surpluses. The decrease in output follows from a lower capital stock, due to crowding-out of private investment by a higher interest rate, and lower employment, mainly due to an increase of real labour costs.

In period 10 the picture is more or less the same as in the fifth period. The major difference is that the outcomes now imply the qualification LOC policy instead of BTN policy. The terms of trade improvement of the passive country pushes real gross value-added (y_x^*) above its reference level. Evidently, real national income (y_d^*) is also above its steady-growth level, since the capital income account surplus has increased as well.

In the long run, the active country strongly benefits from its supply-oriented fiscal expansion. Multifactor productivity is substantially above its steady-growth level. This boosts production capacity (y). Moreover, room is created for crowding-in of private investment. This entails an expansion of the capital stock, which also contributes to higher production capacity. Domestic expenditure remains behind potential output. This follows from both a decreased consumption ratio, as a result of higher taxes, and a lower investment ratio, as a result of a higher real interest rate. Goods market equilibrium is warranted by higher net exports. This requires an improvement in competitiveness. The incurred terms of trade deterioration imply that real gross value-added (y_x) stays somewhat behind output. The terms of trade of the passive country rise, forming the lion's share of higher real gross value-added (y_x^*) there. The capital income account leaves the LOC result unaffected qualitatively, so that this also holds for real national income (y_d). However, it exerts a reasonable effect quantitatively.

Two extreme cases have also been studied. On the one hand, if public capital is totall ineffective ($\varepsilon_g = 0$), the active country is hit by medium- and long-run stagflation. This must obviously be ascribed to the crowding-out of private investment by higher public expenditure. In the fifth period the outcome then must be

qualified as BLOC. Later on, the result is invariably BTS. On the other hand, if public capital is very efficacious ($\varepsilon_g = 0.4$), the short-run outcome changes into BTN. However, the result must be qualified as LOC from the fifth period onward. Notably, in this case the short-run results are less pronounced, from a quantitative point of view, owing to stronger congestion effects. The opposite holds for the medium- and long-run results, owing to stronger effects of public capital on multifactor productivity.

The present analysis can be extended in several ways. First, introduction of rational expectations would obviate the well-known Lucas critique, while shedding a potentially different light on the short and medium run. Secondly, human capital has been ignored completely. Taking account of the productive effects of government outlays on education would certainly benefit the analysis. Thirdly, endogenizing the risk premium for firms as well as a more advanced way of modelling the inter-regional risk premium would certainly be an improvement. Fourthly, coordination of monetary and fiscal policy within a region could be studied. Finally, the simulations suggest that a worldwide stimulus to public investment would be very efficacious. So, international coordination of these policies is another field that could be fruitfully analyzed.

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Appendix A: Parameter values (reference situation)

Elasticity of substitution

$\phi_{kl} = 0.50$	between private capital and labour

Elasticity of

$\varepsilon_g = 0.2$	output of firms with respect to the congestion-corrected public capital stock
$\varepsilon_{i_{k_d}} = 0.11$	private investment with respect to the gap between the desired and the actual stock of private capital
$\varepsilon_{\text{imp}} = 1$	imports with respect to the real exchange rate
$\varepsilon_{m_y} = 1$	money demand with respect to nominal income
$\varepsilon_{m_r} = 0.6$	money demand with respect to the interest rate
$\varepsilon_{rdif_f} = 0.20$	interest rate differential with respect to the net foreign asset position
$\varepsilon_{t_{r_D}} = 5$	wage-tax rate with respect to government interest payments ratio
$\varepsilon_{w_{lm}} = 0.2/0.8$	nominal wages with respect to employment
$\varepsilon_{w_{px}} = 0.85/0.65$	nominal wages with respect to the consumer price index

Initial steady-state ratio of

$\gamma_{c_p} = 0.678$	private consumption to output of firms
$\gamma_{c_g} = 0.068$	material government consumption to output of firms

$\gamma_{d_v} = 0.6$	government debt to output of firms
$\gamma_{exim} = 0.15$	exports/imports to output of firms
$\gamma_i = 0.22$	gross private capital investment to output of firms
$\gamma_{i_g} = 0.034$	gross public capital investment to output of firms
$\kappa = 2$	private capital to output of firms
$\kappa_g = 0.5$	public capital to output of firms

Other non-behavioural parameters

$\delta = 0.08$	depreciation rate of private capital
$\delta_g = 0.038$	depreciation rate of public capital
$\lambda_l = 0.6$	wage share/production elasticity of labour
$\pi = 0.01$	population growth rate
$r = 0.02$	real after-tax interest rate on government bonds
$r_n = 0.072$	real after-tax return on private capital
$r_{av} = 0.06$	average rate of return on private capital and government bonds
$\rho = 0.02$	rate of labour-augmenting technical progress
$\sigma_r = 0.5$	average saving ratio of capitalists/rentiers
$\tau_r = 0.4$	tax rate on profits
$\psi = 0.052$	risk premium for firms in the capital market

Appendix B: Intervals of robustness with respect to real national income (y_d): European fiscal expansion

Parameter value (reference situation)	$t = 1$	$t \to \infty$
ε_g (0.2)	0–0.375	0.01–1
$\varepsilon_{i_{k_d}}$ (0.11)	0.001–∞	0.001–∞
ε_{imp} (1.0)	0.85–∞	0.75–∞
ε_{m_r} (0.6)	0.5–1	0.025–1
ε_{rdif_r} (0.2)	0.01–1	0.04–1
$\varepsilon_{t_{r_D}}$ (5)	0.1–7.5	1–50
$\varepsilon_{w_{px1}}$ (0.85)	0.01–0.99	0–1
$\varepsilon_{w_{px2}}$ (0.65)	0.10–0.95	0–1
$\varepsilon_{w_{im1}}$ (0.2)	0.01–∞	0.01–∞
$\varepsilon_{w_{im2}}$ (0.8)	0.01–2	0.01–∞
ϕ_{kl} (0.5)	0.41–1	0.15–1

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