Crowding out of private and public capital accumulation in an international context

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The paper analyses the impact of government budget deficits in a two-country general equilibrium model with imperfect commodity substitution and imperfect capital mobility. Account is taken of optimizing agents, finite lives, capital accumulation, intertemporal budget constraints for governments and private sectors, current account dynamics and floating exchange rates. The long-run effects of crowding out of private and public capital accumulation are of primary concern in the paper. To satisfy the solvency condition of the governments proportional control rules for taxation and public investment are applied. Numerical methods are used to trace the effects of a unilateral increase in exhaustive government spending.

Keywords: International interdependence; Crowding out; Capital accumulation

Governments run deficits for some time to obtain short-run economic or political targets. In this paper the short-run results of such a policy are put in the background of analysing the long-run consequences of a loose fiscal stance. In an international context government deficits may be reflected in deficits on the current account and such twin deficits have important consequences for long-run welfare. There are a number of interesting and related questions which may be asked in this connection. A rise in government expenditure crowds out private spending. How are the consequences of crowding out spread across different countries? The answer to this question is directly related to the functioning of the international capital market. However, a rise in exhaustive public spending may also crowd out public investment. Empirical evidence of a decline in the share of general government investment spending in a large number of OECD countries is provided by Tanzi and Lutz [21]. Moreover, for the period considered (1970–87) the authors find a negative correlation between capital spending and interest payments in a sample of 18 countries. Public choice considerations may be invoked to stress the likelihood of this kind of crowding out. There are no strong constituencies to protect outlays on public capital formation. Moreover, the benefits to be reaped from public investment are far ahead in the future, so that the political value of such expenditures is relatively low. Therefore, a growth in public debt may in time lead to increases in taxes as well as to changes in the structure of public expenditure with government investment being squeezed out by rising interest payments. If so, the question arises of what price has to be paid in the long run and again to what extent the burden can be shifted towards other nations.

The problems raised above will be discussed by introducing a general equilibrium two-country model with imperfect financial asset substitution and imperfect commodity substitution across countries. The model takes account of optimizing agents, finite lives, capital accumulation, intertemporal budget constraints for the governments and private sectors, current account dynamics and floating exchange rates. It differs from existing two-country optimizing models (eg Buiter [9], Giovannini [11], Van der Ploeg [18], Van de Klundert and Van der Ploeg [15]) in a number of ways. First, although financial capital is highly

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mobile internationally, substitution of assets is assumed to be imperfect. Studies on rates of return provide empirical evidence against the notion that assets are (nearly) perfectly substitutable (cf Bovenberg and Goulder [5]). Second, it is assumed that production of commodities requires social overhead capital, which is accumulated by government investment.

The paper is organized as follows. In the next two sections the model is introduced in some detail, and an overview is presented of the results obtained if the foreign government (say the USA) runs a deficit for some time. The subsequent section discusses numerical exercises, which provide a more elaborate picture of the development of the wealth of nations concerned. The paper closes with some concluding remarks.

A two-country model with imperfect asset and commodity substitution

Consumption and saving decisions

The demand side of each country is made up of identical consumers with a constant probability of death (β) and a constant pure rate of time preference (α) as in the analysis of Blanchard [3]. There is no intergenerational bequest motive. To avoid unintended bequests individuals buy life insurance. The individual born at time $s \leqslant t$ receives (pays) for every period of his life a premium, $\beta W(s,t)$ and at the time of death the individual's net wealth, $W(s,t)$ goes to the life insurance company. The consumers born at time $s \leqslant t$ have homothetic preferences over consumption at time t of home goods, $C_h(s,t)$, and foreign goods, $C_m(s,t)$. Labour supply of individuals is inelastic. Consumers face a two-stage decision problem. In the first stage they decide upon total consumption, $C(s,t)$, in the present period against total consumption later in time. To simplify somewhat it is assumed that the intertemporal elasticity of substitution is unity. In the second stage consumers make an optimal choice with regard to home and foreign goods given total consumption of the first stage problem.

The first stage maximization problem can be stated as:

$$\underset{\{C\}}{\text{Max}}\, U(t) = \int_t^{\infty} \log[C(C_h(s,v), C_m(s,v)] \times \exp((\alpha+\beta)(t-v))\,dv \tag{1}$$

subject to the individual consumer's intertemporal budget constraint,

$$\dot{W}(s,t) = (\tilde{r}(t)+\beta)W(s,t) + Y_L(s,t) - T(s,t) - C(s,t)P_c(t) \tag{2}$$

and the condition precluding Ponzi games:

$$\lim_{t\to\infty} \exp\left[-\int_t^{\infty} (\tilde{r}(\mu)+\beta)\,d\mu\right] W(s,v) = 0 \tag{3}$$

where Y_L denotes labour income, P_c denotes the price index of the consumption basket, Y denotes income received and T denotes lump sum taxes paid. The variable $\tilde{r}$ relates to the average return on the portfolio of domestic residents, who hold domestic and foreign bonds as explained below[1]. The problem can be solved by standard methods (eg Blanchard and Fischer [4]). Applying the relevant aggregation procedure we can write total consumption as:

$$C(s,t)P_c(t) = (\alpha+\beta)(W(s,t)+H(s,t)) \tag{4}$$

where human wealth at time t of an individual born at time s is given by

$$H(s,t) = \int_t^{\infty} [Y_L(s,v) - T(s,v)] \times \exp\left\{-\int_t^{v} (\tilde{r}(\mu)+\beta)\,d\mu\right\} dv \tag{5}$$

The second stage maximization problem can now be formulated as:

$$\underset{\{C_h, C_m\}}{\text{Max}}\, \tilde{U}(C_h(s,t), C_m(s,t)) \tag{6}$$

subject to the budget constraint

$$C_h(s,t) + E(t)C_m(s,t) = C(s,t)P_c(t) \tag{7}$$

where E denotes the real exchange rate ie the price of foreign goods in units of the domestic good, which the individual consumer takes as given. Maximization of the instantaneous utility function, which is assumed to be homothetic, results in the following expressions:

$$C_h(s,t) = \Phi_1(E(t))C(s,t)P_c(t) \qquad \Phi_1' > 0 \tag{8}$$

$$C_m(s,t) = \Phi_2(E(t))C(s,t)P_c(t) \qquad \Phi_2' < 0 \tag{9}$$

Substitution of these outcomes back in the instantaneous utility function leads to an expression for the price index of total consumption:

$$P_c(t) = \Phi_3(E(t)) \tag{10}$$

[1] Denoting the share of domestic bonds in total wealth by λ, the average rate of return is given by $\tilde{r} = \lambda r + (1-\lambda)(r^* + \dot{E}/E)$.

To obtain aggregate results we have to sum over generations. At every instant in time a cohort or generation with a probability of death, β, is born. The size at time t of a cohort born at time $s \leqslant t$ equals $\beta \exp(-\beta(s-t))$. Therefore, total population at time t is $\int_t^\infty \beta \exp(-\beta(s-t))\,ds = 1$. The aggregation procedure is explained in Blanchard [3], Blanchard and Fischer [4] and Buiter [10]. Here it will suffice to give the results. Aggregate consumption follows from Equation (4):

$$C(t)P_c(t) = (\alpha+\beta)(W(t)+H(t)) \tag{11}$$

The solution for aggregate non-human wealth follows from

$$\dot{W}(t) = \tilde{r}(t)W(t) + Y_L(t) - T(t) - C(t) \tag{12}$$

The derivation of (12) made use of the fact that the non-human wealth of newly born individuals must be zero, $W(t,t)=0$, because there are no bequests. The behaviour of aggregate human wealth can be characterized by:

$$\dot{H}(t) = (\tilde{r}(t)+\beta)H(t) - Y_L(t) + T(t) \tag{13}$$

Aggregation over the demand equations (8) and (9) is straightforward and can be left to the reader.

Portfolio choice

It is assumed that financial assets within each country are perfect substitutes but that they are imperfect substitutes across countries. There are several explanations for the apparent imperfect substitutability, but the main point seems to be risk. Individuals may hold portfolios consisting of assets of different countries despite a difference in returns, because of exchange risks or risks of expropriation. Exchange risk could be eliminated by assuming that agents have perfect foresight, so that they can predict changes in the real exchange rate accurately (eg Branson [7], Branson and Henderson [8]). That leaves one with sovereign risk and other forms of uncertainty.

The modelling of imperfect substitution in assets may go along different lines. An elegant manner would be to integrate portfolio choice under uncertainty in the utility maximization problem of households. The introduction of uncertainty is beyond the scope of the present paper. Instead, a compromise procedure as in Goulder and Eichengreen [12], Bovenberg and Goulder [5,6] could have been applied. In these papers the portfolio choice is based on a preference function with the shares devoted to domestic and foreign assets as arguments. Embedding the portfolio preference function in the intertemporal utility function, households make choices with regard to asset holding and consumption in a consistent way.

Here we follow a more direct approach by assuming that the shares of assets of a given country in total wealth depend upon the relative return:

$$\frac{B_h}{W} = \rho_1\left(r - r^* + \frac{\dot{E}}{E}\right) \qquad \rho_1' > 0 \tag{14}$$

$$\frac{EB_m}{W} = \rho_2\left(r - r^* + \frac{\dot{E}}{E}\right) \qquad \rho_2' < 0 \tag{15}$$

where B_h denotes the amount of domestic assets and B_m denotes the amount of foreign assets expressed in units of the foreign good. In contrast to Bovenberg and Goulder [5,6], Equations (14) and (15) take account of exchange rate expectations, although foreign and domestic assets remain imperfect substitutes. Clearly in a model with far-sighted agents the exchange rate should jump in response to news about exogenous variables. It may be argued that the procedure chosen is *ad hoc* and may hamper proper welfare comparisons. However, the argument is not fully convincing as the utility of asset shares remains a rather opaque concept.

Production and capital accumulation

Firms produce under perfect foresight and maximize the present value of the cash flow, V, subject to a concave and twice differentiable production function

$$Y = f(K,S) \quad f_K > 0 \quad f_S > 0 \quad f_{KK} < 0 \quad f_{SS} < 0 \tag{16}$$

where Y denotes aggregate production, K denotes the stock of privately owned capital and S denotes the stock of social overhead capital as in Arrow and Kurz [1]. An empirical justification for including public capital as an argument in the production function is provided by Aschauer [2]. It turns out that the case of constant returns to scale across all factors, private and public, gives better statistical results than the alternative of increasing returns over all inputs. In this case the adding-up constraint requires that the rents from public services are appropriated by the private factors of production. To avoid this complication it will be assumed here that the production function exhibits constant returns with respect to private factors. Labour supply is exogenous by assumption and a flexible real wage rate is supposed to equate labour demand and supply at every moment in time. The demand for labour can therefore be eliminated from the production function.

The remaining problem for the firm is to choose an optimal capital stock. To derive a well behaved

investment function it is necessary to introduce installation cost with respect to newly installed capital (eg Hayashi [14]). The investment expenditure function based on capital accumulation, I, and installation cost is written as:

$$J=g(I,K) \quad g_I>0 \quad g_K<0 \quad g_{II}>0 \tag{17}$$

The decision problem for the representative firm can now be formulated as:

$$\text{Max } V(t)=\int_t^{\infty}[f(K(v),\ S(v))-g(I(v),\ K(v))] \times \exp\left(-\int_t^v r(\mu)\,d\mu\right)dv \tag{18}$$

subject to an initial condition for K and the accumulation equation

$$\dot{K}(t)=I(t)-\delta_K K(t) \tag{19}$$

where δ_K is a constant rate of depreciation. It should be noticed that Equation (18) implies that each country specializes in the production of its own exportable. Moreover, it is assumed that firms finance their investment outlays on the domestic market for loans. Therefore, the domestic interest rate can be used to discount future cash flows.

Denoting the costate variable associated with the stock of capital by Q and applying the maximum principle results in the first order conditions

$$g_I(I(t),\ K(t))=Q(t) \tag{20}$$

$$\dot{Q}(t)=(r(t)+\delta_K)Q(t)-f_K(K(t),\ S(t))+g_K(I(t),\ K(t)) \tag{21}$$

Moreover, the following transversality condition must hold:

$$\lim_{v\to\infty}\exp\left[-\int_t^v r(t)\,ds\right]Q(v)K(v)=0 \tag{22}$$

Equation (20) gives the rate of investment as a function of Tobin's Q. The behaviour of the costate variable Q follows from Equation (21).

The government budget constraint

The government services its debt (D), spends on home goods, levies lump sum taxes and finances the resulting deficit by borrowing. Government spending is split among public consumption (G_c) and public investment (G_I). These assumptions are captured by the government budget constraint:

$$\dot{D}(t)=r(t)\ D(t)+G_c(t)+G_I(t)-T(t) \tag{23}$$

The No Ponzi game (NPG) or solvency condition for the government can be written as:

$$\lim_{t\to\infty}\exp\left[-\int_t^v r(\mu)\,d\mu\right]D(v)=0 \tag{24}$$

Integration of Equation (23) subject to the NPG condition (24) gives:

$$D(t)=\int_t^{\infty}[T(v)-G_c(v)-G_I(v)] \times \exp\left(-\int_t^v r(\mu)\,d\mu\right)dv \tag{25}$$

so that real government debt plus the present value of future government spending has to be paid off by the present value of future lump sum taxes. Notice that the assumption of finite lives (probability of death greater than zero) drives a wedge between the discount rate used to calculate human wealth, $r+\beta$, and the discount rate used to calculate government debt, r. This is the main reason why the Ricardian debt neutrality theorem does not hold, so that the burden of higher taxation can be passed on to future generations.

For the solvency condition of the government to be satisfied, one needs some control rule on taxation or spending. Following Phillips [17] three such rules can be distinguished when applied to taxation:

(i) A proportional policy rule of the type:

$$T(t)=T_0+\xi_1 D(t) \tag{26}$$

(ii) An integral control rule of the type:

$$\dot{T}(t)=\xi_2 D(t) \tag{27}$$

(iii) A derivative policy rule of the type:

$$T(t)=T_0+\xi_2\dot{D}(t) \quad \xi_2>1 \tag{28}$$

These rules have different implications for long-run debt in case of a permanent increase in government spending, starting from a steady state with zero debt. Under rule (iii) government debt falls in the new steady state, so that the rise in exhaustive spending can be financed by a reduction in interest payments. Under rule (ii) long-run debt does not change and taxation

rises just enough to finance the increase in spending, whereas under (i) long-run debt rises and taxation increases to cover both the increase in exhaustive spending and the rise in debt service. Here we will stick to rule (i) as we intend to analyse the consequences of an increase in government debt in the short run as well as in the long run, which may follow from the simple logic behind the proportional policy rule. However, as an alternative to Equation (26) we will consider the case where a permanent increase in public consumption is financed by crowding out of public investment according to:

$$G_I(t)=G_{I_o}-\pi_1 D(t) \tag{29}$$

Finally, it should be noted that the accumulation of social overhead capital is given by:

$$\dot{S}(t)=G_I(t)-\delta_s S(t) \tag{30}$$

where δ_s is a constant rate of depreciation of social overhead capital.

International interdependence

The world consists of two countries with identical structures. The foreign country has similar relationships to the one discussed above and its variables are denoted by an asterisk. There is no mobility of labour or physical capital between the two countries. The condition for equilibrium in the home goods market is given by:

$$Y=C_h+I+G_c+G_I+C_m^* \tag{31}$$

and the one for the foreign goods markets reads:

$$Y^*=C_h^*+I^*+G_c^*+G_I^*+C_m \tag{32}$$

Equilibrium in the market for domestic assets is given by:

$$D+KQ=B_h+B_m^* \tag{33}$$

It is assumed that installation costs are such that marginal Q is average Q (eg Hayashi [14]). The left-hand side of Equation (33) relates to the supply of domestic assets, which differs from non-human wealth by the net claim on foreign assets:

$$W=B_h+EB_m=D+KQ+F \tag{34}$$

so that $F=EB_m-B_m^*$. Asset market equilibrium in the market for foreign assets requires

$$D^*+K^*Q^*=B_h^*+B_m \tag{35}$$

Non-human wealth in the foreign country is equal to

$$W^*=B_h^*+\frac{B_m^*}{E}=D^*+K^*Q^*-\frac{F}{E} \tag{36}$$

The current account consists of net interest payments plus the balance of trade and equals the increase in national wealth:

$$\dot{F}(t)=\left[r^*(t)+\frac{\dot{E}(t)}{E(t)}\right]E(t)B_m(t) -r(t)B_m^*(t)+C_m^*(t)-E(t)C_m(t) \tag{37}$$

An overview of the results

An analytic solution of the complete model is intractable. However, solutions can be obtained for a truncated model, which may serve as a benchmark for a discussion of simulation results. This benchmark model focuses on real exchange rate dynamics and current account dynamics. Investment is ignored and it is assumed that households have static expectations with respect to future income streams. In addition, no account is taken of the dynamics of the government budget constraint. Global results for the benchmark model are presented in the next subsection. Details of the solution are given in the appendix. The effects of an increase in government spending in the full model are discussed in the second subsection, where we shall summarize the main results of our simulations making use of graphics showing the time paths of some key variables in the model. A more detailed discussion of the outcomes will be given in the next section.

The benchmark model

The state variables in the benchmark model are the real exchange rate, which is a forward looking variable, and foreign debt, which is a backward looking variable. The phase diagram for the dynamic system is given in Figure 1. In the appendix it is shown by linearizing the model in the neighbourhood of a steady state solution that both the $\dot{E}=0$ locus and the $\dot{F}=0$ locus are negatively sloped. Moreover, it can be proved that for reasonable values of the parameters the slope of the $\dot{E}=0$ locus is larger in absolute value than the slope of the $\dot{F}=0$ locus. Therefore, the system exhibits saddlepoint stability. The initial equilibrium is at point A in Figure 1.

The negative slope of the $\dot{F}=0$ locus can be explained as follows. Starting from a point on the curve an appreciation of the domestic real exchange rate ($E\downarrow$) induces a trade deficit which is to be offset by rising income on foreign assets through rising foreign claims ($F\uparrow$). Following Stevenson *et al* [20]

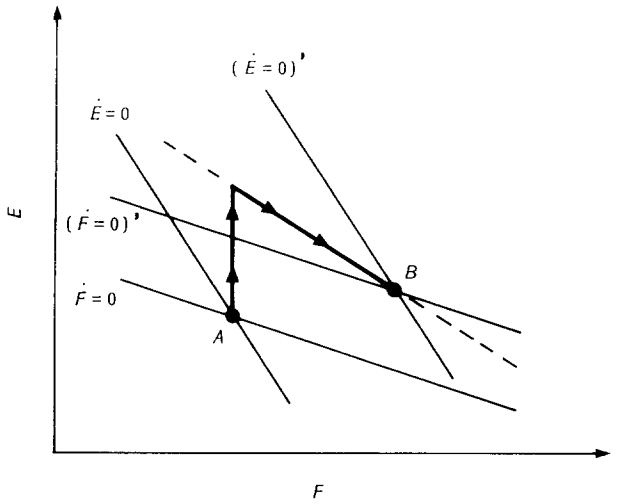

Figure 1. Phase diagram for the dynamic system.

this may be seen as the open economy variant of the coupon effect. The negative slope of the $\dot{E}=0$ locus relates to the role of exchange rate expectations in the model. The announcement of a current account improvement will generate expectations of a fall in the exchange rate. Therefore, an effective increase in foreign assets ($F\uparrow$) accompanied by an appropriate appreciation of the real exchange rate ($E\downarrow$) may keep expectations from changing.

The effects of an increase in government spending abroad, say the USA, are illustrated in Figure 1. As shown in the appendix, the $\dot{E}=0$ locus and the $\dot{F}=0$ locus shift upwards and a new steady state is attained at point *B*. On impact of the shock the real exchange rate jumps towards the stable arm of the saddlepath (the dotted line in Figure 1). A positive demand shock in the USA induces a real dollar appreciation and a current account deficit as net exports are crowded out. Over time the system moves along the stable arm of the saddlepath towards point *B*. US foreign debt rises and a real dollar depreciation is required to restore long-run equilibrium. In the long run the crowding out effect may still dominate the coupon effect, so that the real exchange rate in dollar terms is higher in the new steady state compared to its initial position.

In the complete model there are a number of factors which complicate the picture. First, the foreign government has to finance an increase in exhaustive expenditure. This may lead to a rise in the supply of foreign bonds. Second, increasing interest rates depress private investment so that the supply of goods diminishes. This negative supply effect reinforces the excess demand for US goods and therefore contributes to an appreciation of the real dollar rate. Third, it makes a great difference whether the solvency problem of the government is solved by raising taxes or by cutting public investment. In the next subsection these factors will be taken into account in discussing the effects of an increase in government spending abroad.

The complete model

Some main results of a rise in government spending in the foreign country (say the USA) under a tax rule are shown in Figure 2. On impact there is a real dollar appreciation as US goods are in excess demand. Over time the real exchange rate falls as may be expected. Ultimately, the rate stabilizes at a level above the initial steady-state value. There is no need for a real dollar depreciation in the long run to service foreign debt (coupon effect). Because investment is crowded out US goods remain in short supply compared with the initial situation and the coupon effect is dominated by the crowding out effect.

The long-run results therefore correspond to the outcome in the benchmark model. Foreign debt increases and private consumption in the USA falls substantially. The fall in consumption is the net result of a crowding out effect accompanied by a decline in the stock of capital on the one hand and a positive

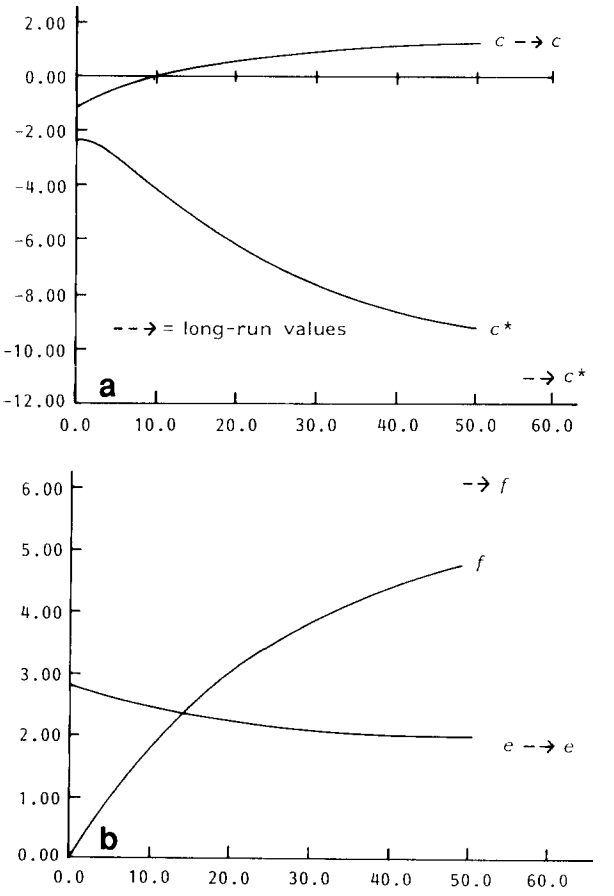

Figure 2. Tax rule.

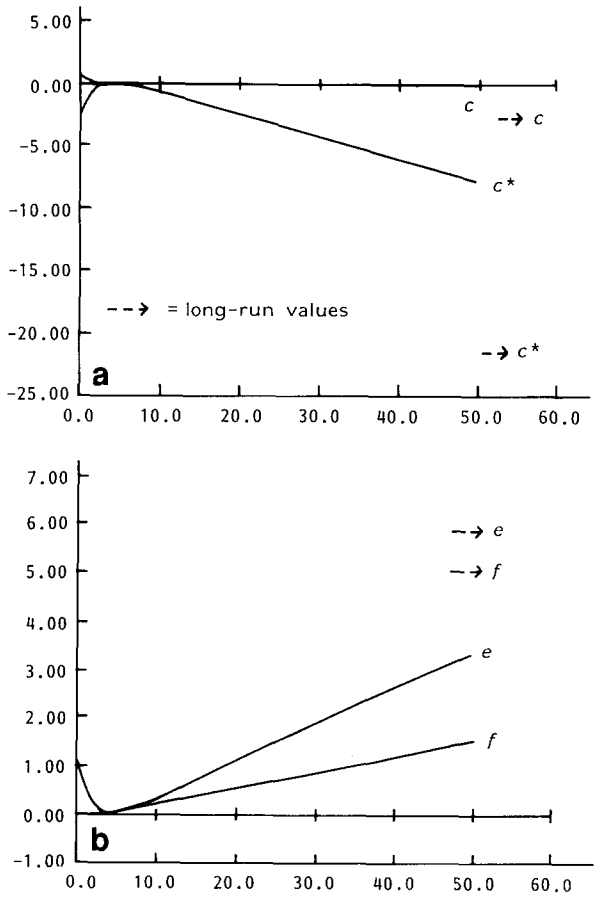

Figure 3. Rule on public investment.

terms of trade effect on the other hand. For Europe the latter effect works, of course, in the opposite direction and consumption increases on balance in this region.

Things are quite different if the solvency of the government is maintained by a control rule on public investment, as appears from Figure 3. Under a rule on public investment the real exchange rate jumps upwards on impact and falls thereafter relatively fast for two reasons. First, as in the other cases discussed, the coupon effect necessitates a real dollar depreciation. Second, aggregate demand falls in the USA as the government spends less on domestic goods for public investment. The real dollar depreciation checks the increase in foreign debt.

The spending effect of public investment precedes the capacity effect, but crowding out of government investment leads to a fall in social overhead capital in the course of time. As a result output decreases substantially in the USA. The fall in output is caused by the combined effect of a decline in private capital and a decline in social overhead capital. When these developments acquire momentum things are reversed because the supply effect then induces a gradual real dollar appreciation. As the real dollar appreciation continues foreign debt rises further because US goods remain in excess demand. Long-run consumption falls substantially in the US economy despite a significant improvement in the terms of trade. The outcome for European welfare remains to be seen. As will be shown in the next section, long-run aggregate consumption increases slightly in Europe despite the adverse terms of trade effect.

Finally, it should be noticed that it takes more time to attain the steady-state values of the variables under a rule on public investment compared with a stabilizing tax rule. In the former case the dynamic process is complicated by the accumulation of public capital which interacts with the accumulation of private capital.

Simulation results: a closer look

The numerical effects of an increase in US government spending by 5% of GNP are presented in Tables 1 and 2. The results under a tax rule to assure government solvency are discussed in the first subsection; the numerical outcomes under a rule on public investment are then looked at. Computations are based on a algorithm presented in Van der Ploeg and Markink [19].[2]

A fiscal deficit under a tax rule

The effects of a rise in government spending under a tax rule are shown in Table 1. As the model assumes forward looking behaviour of agents it may be useful to discuss the long-run results first. Government debt in the foreign country, say the USA, increases substantially in the long run. Therefore the interest rate on dollar denominated bonds rises, which leads to a crowding out of investment in the US economy. Because foreign and domestic bonds are imperfect substitutes the rise in the European interest rate stays behind the increase in the US interest rate. Investment in Europe is therefore less harmed. The rise in interest rates and fall in output (as a result of the decline in capital) reduce human wealth in both regions. The decline in human wealth is, of course, more pronounced in the USA where taxes must be increased to eliminate the government deficit.

With respect to non-human wealth the developments across countries are qualitatively different. In the USA non-human wealth declines for two reasons. First, as noted above the capital stock falls. Second, external

[2] To apply the algorithm the model has to be linearized around a steady-state solution. The log linear version of the model along with the parameter values applied in the simulations is given in the appendix.

Table 1. Fiscal deficit in the USA under a tax rule.

Variable[a]	Period 0	5	∞
Europe			
Total consumption (c)	−1.17	−0.47	1.62
Consumption domestic goods (c_h)	0.24	0.84	2.55
Consumption foreign goods (c_m)	−5.40	−4.38	−1.17
Non-human wealth (w)	−0.38	0.10	3.57
Human wealth (h)	−0.78	0.50	−3.86
Capital stock (k)	0	−0.39	−2.66
Interest rate (r)	−0.10	0.06	0.14
Government debt (d)	0	0.06	0.30
Domestic bonds (b_h)	−0.59	−0.58	1.56
Foreign bonds (b_m)	−2.40	0.22	9.75
USA			
Total consumption (c^*)	−2.43	−2.94	−10.76
Consumption domestic goods (c_h^*)	−3.84	−4.25	−11.68
Consumption foreign goods (c_m^*)	1.80	0.97	−7.97
Non-human wealth (w^*)	−1.60	−1.70	−10.39
Human wealth (h^*)	−9.27	−11.19	−14.55
Capital stock (k^*)	0	−1.36	−8.97
Interest rate (r^*)	−0.09	0.22	0.46
Government debt (d^*)	0	10.26	12.13
Domestic bonds (b_h^*)	−1.40	−1.01	−8.38
Foreign bonds (b_m^*)	0.42	−1.82	−16.57
World			
Real exchange rate (e)	2.82	2.61	1.86
US foreign debt (f)	0	0.93	5.64

[a] Variables are expressed as percentage deviations from initial steady state values (except f for which it is the deviation as a percentage of W and r, r^*, for which it is 100 times the absolute deviations).

Table 2. Fiscal deficit in the USA under a rule on public investment.

Variable[a]	Period 0	5	∞
Europe			
Total consumption (c)	0.83	−0.32	0.05
Consumption domestic goods (c_h)	1.42	−0.30	3.26
Consumption foreign goods (c_m)	−0.92	−0.37	−9.57
Non-human wealth (w)	−0.41	0.22	2.99
Human wealth (h)	7.29	−2.44	−3.66
Capital stock (k)	0	0.02	−3.05
Interest rate (r)	0.72	−0.03	0.13
Government debt (d)	0	0.08	0.30
Domestic bonds (b_h)	−0.29	0.07	1.91
Foreign bonds (b_m)	−2.06	0.79	0.87
USA			
Total consumption (c^*)	−2.71	0.19	−20.35
Consumption domestic goods (c_h^*)	−3.29	0.17	−23.56
Consumption foreign goods (c_m^*)	−0.96	0.24	−10.72
Non-human wealth (w^*)	−0.13	−0.36	−21.66
Human wealth (h^*)	−4.85	−2.94	−23.12
Capital stock (k^*)	0	−0.71	−23.32
Interest rate (r^*)	2.28	−0.02	0.31
Government debt (d^*)	0	10.48	11.79
Domestic bonds (b_h^*)	−2.66	1.12	−20.59
Foreign bonds (b_m^*)	−0.89	0.39	−19.54
World			
Real exchange rate (e)	1.17	0.03	6.42
US foreign debt (f)	0	1.63	5.36

[a] See Table 1.

debt rises as a result of deficits on the current account. In Europe the stock of capital declines somewhat but the stock of foreign assets rises and as a result non-human wealth increases on balance. This explains the rise in European consumption, whereas total consumption in the USA falls significantly despite an increase in the US terms of trade. A real dollar appreciation leads to a decline in consumers prices in the USA and vice versa in Europe. The outcome with respect to the real exchange rate is the net result of opposing forces. The relatively large decline in the US output raises the relative price of US goods (supply effect). In contrast, the interest payments on foreign debt (coupon effect) require a real dollar depreciation. In our exercise the supply effect dominates the coupon effect, as illustrated in Table 1.

The short-run picture is quite different. On impact of the shock human wealth falls in the USA which leads to a decline in aggregate consumption. It should be observed in this connection that human wealth is a forward looking variable which reflects the fall in income and rise of interest rates in the future. In Europe human wealth declines slightly, which induces a fall in consumption expenditure. The volume of consumption declines even more, because of a rise in the consumption price level. There is a real dollar appreciation on impact, as US goods are in excess demand. The European import of goods declines substantially, whereas import in the USA rises. A similar pattern can be deduced with respect to the allocation of domestic and foreign bonds.

As can be observed, the results differ from the standard Mundell–Fleming model, where an increase in government spending is a locomotive policy in the short run. In the present model a rise in government spending in the USA is a beggar thy neighbour policy in the short run, but it allows Europe to have a higher welfare level in the long run. Instantaneous welfare in the USA falls gradually, but it should be noted that the increase in public expenditure may convey direct utility to consumers. The rise in the real interest rate is higher in the USA over the entire period, because the supply of US bonds increases until a new steady state is attained.

A fiscal deficit under a rule on public investment

The budget deficit in the USA is now closed by crowding out of government investment. The effects of an increase in exhaustive government spending are given in Table 2. The decline in the stock of social overhead capital leads to a deterioration of the marginal productivity of privately owned capital. As a result, the accumulation of capital is seriously affected in the USA in the long run. Inspection of the long-run results in Tables 1 and 2 shows to what extent

the stock of capital is reduced under an investment rule in comparison with a tax rule. As a result of the dramatic decline in the stock of capital US output falls substantially. The resulting excess demand for goods originating in the USA induces a real dollar appreciation of about 6.5% in the long run. Total consumption benefits from the improvement in the terms of trade; nevertheless the ultimate result is strongly negative because real human and non-human wealth is severely depressed. The long-run effect on European consumption and welfare is slightly positive despite the deterioration in the European terms of trade. US foreign debt changes by about the same amount in both cases. The same holds true for public debt in the USA, so that the shocks are on equal footing in the case of a tax rule and in the case of a rule on public investment. However, different stories lie behind these more or less equal long-run results. This is best seen by turning to the short-run and medium-run effects in the case of a rule on public investment.

It should be noticed that crowding out on impact of the shock is now governed by a rise in interest rates. This result contrasts with the impact effects in the case of a tax rule, where crowding out takes the form of a reduction in US exports. In the present case this phenomenon is less pronounced, so that the real dollar appreciation on impact is moderate compared to the outcome in Table 1. The explanation for this difference in results is clear, but at the same time somewhat complicated. In the case of a rule on public investment there is a strong dollar depreciation in the medium run, the reason for which will be given shortly. An expected depreciation of the dollar reduces the average rate of return on the portfolio of European households. Consequently, human wealth rises and aggregate consumption in Europe increases. To restore equilibrium in the markets for goods the interest rates have to rise.

In the medium run the dollar depreciates relatively fast in real terms under the influence of the coupon effect (connected with an increase in external debt) and a reversed crowding out effect (connected with the decline in public investment necessary to stabilize the government budget). The real exchange rate attains its lowest value at $t=5$. Thereafter, the process is reversed as excess demand for US denominated goods again becomes the dominating factor. But this time excess demand is not caused by an autonomous shock as at $t=0$, but by the fall in US supply under the influence of a decline in the stock of private and social capital. The parabolic shape of the time path of the real exchange rate of the dollar is typical for the case of a rule on public investment compared with a stabilizing rule based on taxes. The developments in the medium run are thus not indicative for the long-run results, which may come as a surprise.

Concluding remarks

This paper focuses on imbalances in the world economy caused by a unilateral increase in government spending, say in the USA. The results depend on the type of control rule applied to maintain solvency of the governments. It is argued that proportional rules are most likely to be applied from a political point of view.

An increase in US government spending under a tax rule induces a real dollar appreciation and crowding out of exports in the short run. Aggregate consumption and investment as well as exports are choked off to maintain equilibrium in the goods market. Aggregate consumption in Europe falls too, because the European terms of trade deteriorate.

In the longer run developments are to a large extent determined by the process of capital decumulation, which is most pronounced in the spending country. Imperfections in the capital markets restrict the rise in European interest rates so that there capital accumulation is less affected. As US external debt rises the dollar depreciates in real terms, but the coupon effect is mitigated by the supply effect, implying that mutations in the real exchange rate are moderate. In the long run the US terms of trade improve but aggregate (private) consumption falls along with a decline in real wealth. In contrast, aggregate consumption in Europe rises as a result of the increase in (net) foreign wealth.

Under a rule on public investment private and social overhead capital are crowded out in concert. Real wealth and aggregate consumption decline substantially. Movements in the real exchange rate are now primarily governed by the expenditure and capacity effects of changes in public investment. In the long run the terms of trade of the US economy improve significantly. As a consequence long-run aggregate consumption in Europe increases only slightly.

The examples given illustrate the dangers of short-sighted economic policy measures if account is taken of their full long-run implications. Government debt imposes a burden on future generations if as a result capital accumulation is impaired. Moreover, imperfections in capital markets reduce the negative spill over effects to other regions and therefore increase the long-run burden for the (net) debtor country. Finally, it should be noticed that the situation may even be worse than shown in the paper. A fall in capital accumulation may affect other determinants of economic growth as emphasized in recent studies (eg Lucas [16], Grossman and Helpman [13]). Subsequent contributions on the long-run effects of crowding out could therefore benefit from results obtained by this new theory of economic growth.

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Appendix

The linear version of the complete model

The model presented in the paper is linearized around a steady-state solution. Lower-case letters denote percentage deviations from the steady-state solutions of the corresponding variables denoted by upper-case letters. An exception is the rate of interest, which is measured as an absolute deviation from the initial steady state value ($\bar{r}$) which is equal across countries.

Aggregate consumption

$$c + p_c = \zeta w + (1-\zeta)h \qquad \zeta \equiv \frac{W}{W+H} \tag{38}$$

Consumption of domestic goods

$$c_h = c + (1-\mu)\varphi e \qquad \mu \equiv \frac{C_h}{C} \tag{39}$$

Consumption of foreign goods

$$c_m = c - \mu\varphi e \tag{40}$$

Consumers' price

$$p_c = (1-\mu)e \tag{41}$$

Private investment

$$i = k + \frac{\kappa}{\delta_k} q \tag{42}$$

Production

$$y = vs + \alpha l + (1-\alpha)k \tag{43}$$

Aggregate demand

$$y=\gamma_c c_h+\gamma_i i+\gamma_g g_i+(1-\gamma_c-\gamma_i-\gamma_g)c_m^*+g_c \tag{44}$$

$$\gamma_c=\frac{C_h}{Y} \qquad \gamma_i\equiv\frac{I}{Y} \qquad \gamma_g\equiv\frac{G_i}{Y}$$

Demand domestic bonds

$$\lambda(b_h-w)=\rho(r-r^*-\dot{e}) \qquad \lambda\equiv\frac{B_h}{W} \tag{45}$$

Demand foreign bonds

$$(1-\lambda)(b_m+e-w)=-\rho(r-r^*-\dot{e}) \tag{46}$$

Non-human wealth

$$w=\eta(k+q)+(1-\eta)d+f \qquad \eta\equiv\frac{K}{W} \tag{47}$$

Equilibrium bonds market

$$\eta(k+q)+(1-\eta)d=\lambda b_h+(1-\lambda)b_m^* \tag{48}$$

Human wealth

$$\dot{h}=(\bar{r}+\beta)h+\lambda r+(1-\lambda)(r^*+\dot{e})-(\bar{r}+\beta)(y-t) \tag{49}$$

Tobin's q

$$\dot{q}=(\bar{r}+\delta_k)q+r-(\bar{r}+\delta_k)(y-k) \tag{50}$$

Accumulation of private capital

$$\dot{k}=\delta_k(i-k) \tag{51}$$

Accumulation of social overhead capital

$$\dot{s}=\delta_s(g_i-s) \tag{52}$$

Government budget constraint

$$\dot{d}=\bar{r}d+r+\psi(g_c-t)+\psi\gamma_g g_i \qquad \psi\equiv\frac{Y}{D} \tag{53}$$

Solvency rules

$$t=t_0+\frac{\xi_1}{\psi}d \tag{54}$$

$$g_i=g_{i_0}-\frac{\pi_1}{\psi\gamma_g}d \tag{55}$$

Balance of payments constraint

$$\dot{f}=\bar{r}f+(1-\lambda)(r^*+\dot{e}-r)+\chi(c_m^*-e-c_m) \qquad \chi\equiv\frac{C_m^*}{W} \tag{56}$$

$$\chi\equiv(1-\gamma_c-\gamma_i-\gamma_g)(1-\eta)\psi$$

Coefficients which are not defined are taken from the original model or are explained below. Equations (39) and (40) are obtained from an instantaneous CES utility function:

$$\tilde{U}=[aC_h^{\omega}+(1-a)C_m^{\omega}]^{1/\omega}$$

with elasticity of substitution $\varphi=1/1-\omega$ and preference parameter, a. The derivation of the investment equation (42) and the equation for the costate variable q is based on an investment expenditure function with quadratic cost of adjustment in net investment:

$$J=I+\frac{(I-\delta K)^2}{2\kappa K}$$

and a Cobb-Douglas production:

$$Y=vS^{\nu}(L^{\alpha}K^{1-\alpha})$$

Linearization of the other equations is straightforward. It should be noted that deviations of lump-sum taxes (t) and government consumption (g_c) are expressed as a percentage of initial output, whereas the deviation of external debt is expressed as a percentage of initial wealth. This is necessary because in the initial steady state these variables are assumed to be zero.

The linearized equations for the foreign country are similar to (38)–(56). The model can be solved for 23 output variables (ie $c, p_c, c_h, c_m, i, y, b_h, b_m, w, r, t, (g_i)$ for both countries and e) and 12 state variables (k, h, s, d, f, q for both countries). Invoking Walras's law one of the equilibrium conditions can be eliminated, so that the number of equations equals the number of variables. There are four forward looking state variables (h, q, for both countries) and nine backward looking state variables, but the variable f^* can be omitted for convenience.

The numerical examples are based on the following plausible parameter values.

Households

$\varphi=2$ $\mu=0.75$ $\zeta=0.8$ $\beta=0.02$

$\rho=5$ $\lambda=0.8$

Firms

$\nu=0.2$ $\alpha=0.68$ $\kappa=0.125$ $\delta_k=0.025$

Government

$\psi=1$ $\delta_s=0.02$ $\xi_1=0,0.5$ $\pi_1=0,0.5$

Miscellaneous

$\gamma_o=0.5$ $\gamma_i=0.2$ $\gamma_g=0.1$ $\eta=0.8$ $\bar{r}=0.05$

In all cases considered the model exhibits saddlepath stability.

The benchmark model

The benchmark model is obtained by ignoring investment and capital, assuming static expectations of households and eliminating the government budget constraint (including the solvency rules). The only exogenous variable taken into account is exhaustive government spending.

The log-linear version of the model can then be written as:

Domestic country	*Foreign country*
$c+(1-\mu)e=\zeta w-\xi r$	$c^*-(1-\mu)e=\zeta w^*-\xi r^*$
$c_h=c+(1-\mu)\varphi e$	$c_h^*=c^*-(1-\mu)\varphi e$
$c_m=c-\mu\varphi e$	$c_m^*=c^*+\mu\varphi e$
$\mu c_h+(1-\mu)c_m^*+g_c=0$	$\mu c_h^*+(1-\mu)c_m+g_c^*=0$
$\lambda(b_h-w)=\rho(r-r^*-\dot{e})$	$\lambda(b_h^*-w^*)=-\rho(r-r^*-\dot{e})$
$(1-\lambda)(b_m+e-w)=-\rho(r-r^*-\dot{e})$	$(1-\lambda)(b_m^*-\dot{e}-w^*)=\rho(r-r^*-\dot{e})$
$w=f$	$w^*=-f$

International interdependence

$$\dot{f}=\bar{r}f+(1-\lambda)(r^*+\dot{e}-r)+\chi(c_m^*-c-c_m)$$

$$\lambda b_h+(1-\lambda)b_m^*=0$$

There are no taxes, so that human capital only depends on the rate of interest. Output is fixed and the initial current account is in equilibrium. As a result we have $\mu=C_h/C=C_h/Y$.

Substitution of the equations for both countries in the two equations, which characterize international interdependence, yields a system of two differential equations in e and f:

$$\dot{e}=\left[\frac{1-\lambda}{2\rho}+\frac{2(1-\mu)\{2\mu(\varphi-1)+1\}}{\xi(2\mu-1)}\right]e+\left[\frac{2\zeta}{\xi}+\frac{2\lambda-1}{2\rho}\right]f+\frac{1}{\xi(2\mu-1)}(g_c-g_c^*)$$

$$\dot{f}=\left[\bar{r}+\frac{(2\lambda-1)(1-\lambda)}{2\rho}\right]f+\left[\frac{\chi\{2\mu(\varphi-1)+1\}}{2\mu-1}+\frac{(1-\lambda)^2}{2\rho}\right]e+\frac{\chi}{2\mu-1}(g_c-g_c^*)$$

Assuming that the Marshall–Lerner conditions are fulfilled and assuming local goods preference $\mu>0.5$ as well as local asset preference $\lambda>0.5$ the $\dot{e}=0$ locus and the $\dot{f}=0$ locus will both have a negative slope. For saddlepoint stability it is required that the $\dot{f}=0$ locus is flatter than the $\dot{e}=0$ locus as illustrated in Figure 4. The condition on the relative position of both curves can be expressed as

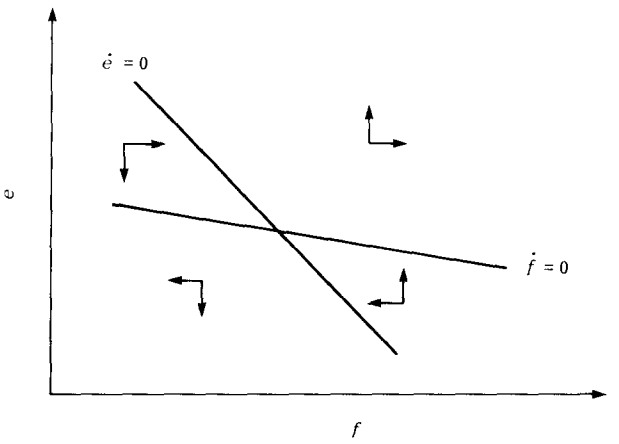

Figure 4. Saddle point stability.

$$\frac{\dfrac{2\zeta}{\xi}+\dfrac{2\lambda-1}{2\rho}}{\dfrac{1-\lambda}{2\rho}+\dfrac{2(1-\mu)\{2\mu(\varphi-1)+1\}}{\xi(2\mu-1)}}>\frac{\dfrac{\bar{r}}{1-\lambda}+\dfrac{2\lambda-1}{2\rho}}{\dfrac{1-\lambda}{2\rho}+\dfrac{\chi\{2\mu(\varphi-1)+1\}}{(1-\lambda)(2\mu-1)}}$$

In the present model we have $\chi=(1-\mu)\psi$. Therefore, the denominators in the inequality above will be equal if $\psi=2(1-\lambda)/\xi$. In that case the condition can be reduced to

$$\xi<\frac{2(1-\lambda)\zeta}{\bar{r}}$$

which sets an upper bound on the interest elasticity of consumption. This condition may be fulfilled for a realistic range of parameter values. However, the denominators do not need to be equal. The denominator on the right-hand side of the inequality may be smaller, which sets a lower bound on the income–wealth ratio in the initial situation:

$$\psi\geq\frac{2(1-\lambda)}{\xi}$$

Taken together both conditions are too strong. More generally, ψ should not be too small for the inequality to hold, which sounds reasonable.