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FISCAL POLICY AND FINITE LIVES IN INTER-
DEPENDENT ECONOMIES WITH REAL AND NOMINAL
WAGE RIGIDITY

by

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and
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October 1988

FISCAL POLICY AND FINITE LIVES IN INTERDEPENDENT ECONOMIES
WITH REAL AND NOMINAL WAGE RIGIDITY

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ABSTRACT

A two-country, perfect-foresight model with finite lives, intertemporal budget constraints for the governments and private sector agents, current-account dynamics, uncovered interest parity, floating exchange rates, imperfect substitution between home and foreign goods, international labour immobility, real wage rigidity at home (Europe) and nominal wage rigidity abroad (US) is formulated and its steady-state and transient properties are analysed. Numerical simulation is used to analyse the spill-over effects of various policy options. First, the impact, transient and steady-state spill-over effects of an increase in European government spending are contrasted with the corresponding effects of an increase in US government spending when a tax rule is used to stabilise the government debt. Second, some aspects of 'Reaganomics' are discussed which is relevant when cuts in US taxes gradually lead to increases in US government debt and only then to cuts in US government spending. Third, the Sargent-Wallace arguments about unpleasant monetarist arithmetic are reconsidered within a two-country model. Finally, the spill-over effects of supply-side policies are discussed.

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1. Introduction

In the traditional one-country Mundell-Fleming world with floating exchange rates and perfect capital mobility a fiscal expansion leads to an incipient rise in the interest rate and capital inflows, which are choked off by an appreciation of the exchange rate. The contraction in net exports completely crowds out the increase in government spending. The Mundell-Fleming model assumes fixed nominal wages and only considers aggregate demand. However, real wage rigidity in aggregate supply reverses the qualitative nature of the policy conclusions. A fiscal expansion now leads to an appreciation of the real exchange rate and a cut in the wedge between the producers' and consumers' wage, so that employment and output increase (Casas, 1975; Argy and Salop, 1979; Sachs, 1980; van de Klundert and van der Ploeg, 1987b).

In the two-country Mundell-Fleming world a home fiscal expansion increases the world interest rate, which reduces the demand for money, exerts an upward pressure on the price level, erodes the real value of the wage and therefore increases aggregate supply both at home and abroad. The appreciation of the home currency and the resulting increase in net exports of the foreign country increases the demand for foreign goods, despite the rise in the interest rate. Because fiscal expansion is a locomotive policy in a Mundell-Fleming world, it can be argued that in the absence of international policy coordination there is a deflationary bias in fiscal policy and therefore too much unemployment. However, when both countries have real rather than nominal wage rigidity, a fiscal expansion is a beggar-thy-neighbour policy as the associated appreciation of the real exchange rate increases the wedge between the foreign producers' and consumers' wage and therefore reduces foreign output and employment (Argy and Salop, 1983; Oudiz and Sachs, 1984; van der Ploeg, 1987). Absence of international policy coordination now implies that both countries adopt a too loose fiscal stance, because each country ignores the adverse effects of a fiscal expansion on the other country's levels of employment and output.

However, there is a reasonable amount of evidence that Europe has real wage rigidity and that the US has nominal wage rigidity (e.g.,

Branson and Rotemberg, 1980; Bruno and Sachs, 1985; van der Ploeg, 1987b). This may be because the European countries have a strong degree of indexation of wages to consumers' prices whereas the US has a significant proportion of overlapping nominal wage contracts. In that case, a European fiscal expansion raises world interest rates, reduces money demand in the US and thus increases prices in the US which cuts the US real wage and boosts employment and output in the US. Hence, a European fiscal expansion is a locomotive policy. On the other hand, a US fiscal expansion is, typically, a beggar-thy-neighbour policy (also see Argy and Salop, 1983). This implies that, in the absence of international policy coordination, the European fiscal stance is too tight from the US point of view and too loose from the European point of view whilst the US fiscal stance is, typically, too loose (van der Ploeg, 1987b).

Such asymmetries in aggregate supply allow one to understand why the substance of the policy debate about the performance of the OECD economies seems to be concerned with the relative tightness of the European fiscal stance and the relative looseness of the US fiscal stance and to understand why recovery in Europe seems so hard. However, it is not clear that the ad-hoc IS/LM/AS two-country models are well suited to address issues of international interdependence and policy coordination. Firstly, a considerable part of the policy debate is about the unsustainability of the trade deficits and government budget deficits of the US and the possible adverse effects these might have on the European economies. The tax cuts that have been recently implemented in the US have resulted in increases in the US deficits and government borrowing, which will have to be paid off by future cuts in US government spending and/or future increases in US taxes (including seigniorage revenues). In other words, it is vital in the discussion of international policy interdependence to allow for the intertemporal budget constraints of governments and private sector agents, to allow for current-account dynamics, and to allow for wealth effects in aggregate demand. It is also important for these policy discussions to allow government debt to be a part of private sector wealth. Secondly, ad-hoc models go together with ad-hoc social welfare functions which, typically, depend on squared deviations of output and inflation from their desired levels. It therefore seems desirable to specify a two-country model with micro foundations, because then a

proper welfare analysis based on gross consumers' surplusses is feasible.

Hence, the objective of this paper is to reconsider the nature of the short-term and long-term international spill-over effects of changes in government spending, taxation and monetary policy in a two-country model with micro foundations, intertemporal government budget constraints, current-account dynamics, real wage rigidity at home (Europe) and nominal wage rigidity abroad (the US). In order to relax the Ricardian debt neutrality proposition and to give a non-trivial role for fiscal policy, it is assumed that current generations can pass the burden of higher taxation on to future generations. This happens when there is no intergenerational bequest motive and either lives are finite (Yaari, 1965; Blanchard, 1985) and/or there is population growth (Weil, 1986; Buiter, 1988). This paper adopts the first possibility. It extends Buiter's (1987a) two-country model (and the infinite-lives, two-country model of Lipton and Sachs (1983)) to allow for real and nominal wage rigidity, rather than for labour market clearing in both countries, and to allow for money, but it is more restrictive as it abstracts from capital accumulation.

Section 2 formulates a two-country, perfect-foresight model with finite lives, intertemporal budget constraints for the governments and private sector agents, current-account dynamics, uncovered interest parity, floating exchange rates, imperfect substitution between home and foreign goods, international labour immobility, real wage rigidity in Europe (home) and nominal wage rigidity in the US (abroad). It leads to eight nonlinear differential equations in terms of home and foreign consumption, home and foreign real money balances, home and foreign government debt, net foreign assets and the foreign nominal wage (normalised by the foreign nominal money supply) and two nonlinear equations in terms of the real exchange rate and the real interest rate. Section 3 discusses the steady-state properties. Inflation is in the long run a monetary phenomenon and foreign output and employment are at their natural rates. An increase in home government spending or a cut in taxation leads in the long run to a fall in the world real interest rate, an appreciation of the real exchange rate and an increase in home output and employment. An increase in home monetary growth has no real effects in the long run;

it simply leads to a one-for-one increase in the home inflation rate and the home nominal interest rate. A cut in the home real wage or an increase in the foreign natural rate of unemployment leads to a depreciation of the real exchange rate and an increase in home output. An increase in foreign government spending or a cut in foreign taxation leads in the long run to a fall in the world real interest rate, an appreciation of the foreign real exchange rate and a fall in home output. Section 4 discusses various dynamic policy simulations with the aid of a multiple-shooting algorithm. First, the impact, transient and steady-state spill-over effects of an increase in European government spending are contrasted with the corresponding effects of an increase in US government spending when a tax rule is used to stabilise the government debt in each country. Particular attention is paid to the effects on government borrowing and foreign debt as well as to the real effects. Second, some aspects of 'Reaganomics' are discussed. The main point is that cuts in US taxation gradually lead to increases in US government debt and only then to cuts in US government spending (cf., Blanchard, 1987). The political economy of fiscal deflation for the US is such that a rule for government spending to stabilise the government debt is, perhaps, more realistic than a tax rule. Third, the Sargent-Wallace (1981) arguments about unpleasant monetaristic arithmetic are reconsidered. When there is no tax rule or government spending rule to stabilise the government debt and when there is a ceiling to the amount of government bonds the private sector is prepared to purchase, an excess of government spending over taxes plus seigniorage revenues must eventually be financed by either an increase in monetary growth or a structural fiscal adjustment. In the former case, tight money today implies high inflation tomorrow and, under perfect foresight, possibly high inflation today. Also, in the process the government debt has increased and therefore one ends up with a permanently higher inflation rate in order to meet the interest payments on the additional government debt (van Wijnbergen, 1985). In the latter case, one ends up with either a permanently lower level of government spending or a higher level of taxation, which one could refer to as unpleasant fiscal arithmetic. Finally, the implications of supply-side improvements are briefly discussed. Section 5 summarises the results on international policy interdependence and briefly discusses the implications for international policy coordination.

2. A two-country model with real wage rigidity at home and nominal wage rigidity abroad

2.1. Finite lives and the individual's consumption and savings decisions

The demand side of each economy is made up of identical consumers with constant life expectancy. There is no intergenerational bequest motive, as in the analysis of Blanchard (1985). The (notional) supply of labour at time t of an individual born at time $s \leq t$ is inelastic and rationed due to a too high real wage arising from either real or nominal wage rigidity. The consumers born at time $s \leq t$ have Cobb-Douglas preferences over the consumption at time t of private home goods, $c_d(s,t)$, private foreign goods, $c_m(s,t)$, publically provided home goods, $G_d(t)$, publically provided foreign goods, $G_m(t)$, and real money balances, $m(s,t)$. Feenstra (1985) provides a justification, based on liquidity costs, for entering money in the utility function. Government spending usually gives utility, although it may be of the 'hole-in-the-ground' variety. Consumers have an intertemporal elasticity of substitution of unity, so that the consumer born at time $s \leq t$ faces the following problem at time t : Choose $c_d(s,t)$, $c_m(s,t)$ and $m(s,t)$ for $t \geq s$ to maximise the utility function,

$$U(t) = \int_s^t \log[c_d(s,v)^{\gamma_1} c_m(s,v)^{\gamma_2} m(s,v)^{\gamma_3} G_d(v)^{\gamma_4} G_m(v)^{\gamma_5}] \exp[(\alpha+\beta)(t-v)] dv, \quad \gamma_i \geq 0, \quad \gamma_1 + \gamma_2 + \gamma_3 = 1, \quad (2.1)$$

subject to the individual consumer's flow budget constraint,

$$\begin{aligned} dn(s,t)/dt = & [r(t) + \beta] n(s,t) + w(t) l(s,t) + \pi(s,t) - z(s,t) \\ & - c(s,t), \end{aligned} \quad (2.2)$$

and the condition precluding Ponzi games,

$$\lim_{t \rightarrow \infty} e^{\rho t} \left(- \int_s^t [r(u) + \beta] du \right) n(s,t) = 0, \quad (2.3)$$

where total consumption is defined as

$$c(s,t) \equiv c_d(s,t) + v(t)c_m(s,t) + i(t)m(s,t), \quad (2.4)$$

the nominal interest rate is defined as

$$i(t) \equiv r(t) + p(t), \quad (2.5)$$

α denotes the subjective rate of time preference, β denotes the constant instantaneous probability of death, $w(t)$, $r(t)$, $p(t) \equiv (dP(t)/dt)/P(t)$, $P(t)$ and $v(t)$ denote the real wage, the real interest rate, the inflation rate, the price level and the real exchange rate (the price of foreign goods in terms of home goods) at time t , respectively, and $l(s,t)$, $n(s,t)$, $\pi(s,t)$ and $z(s,t)$ denote employment, real non-human wealth, profits and lump-sum taxation at time t of an individual born at time $s \leq t$, respectively. The individual consumer receives (pays) for every period of his life a premium, $Bn(s,t)$, and at the time of death the individual's net wealth (debt) goes to (is cancelled by) the life insurance company. The premium is actuarially fair, so that the life insurance (or annuities) market is efficient. Equation (2.3) ensures that the individual cannot roll over his debt forever. The consumers maximise expected utility, so that the probability of death is added to the subjective rate of time preference. Total consumption consists of consumption of home and foreign goods plus the interest foregone on money holdings.

The first-order conditions for the individual consumer yield $c_d(s,t) = \gamma_1 c(s,t)$, $c_m(s,t) = \gamma_2 c(s,t)/v(t)$, $m(s,t) = \gamma_3 c(s,t)/i(t)$ and the 'tilt' of the total consumption function, $dc(s,t)/dt = (r(t) - \alpha) c(s,t)$. The individual consumer ensures that the marginal rate of substitution between home goods and foreign goods equals the real exchange rate and between home goods and real money balances equals the opportunity cost of holding real money balances, i.e., the nominal interest rate. The assumption of Cobb-Douglas preferences implies that the elasticities of imports with respect to the real exchange rate and of money demand with respect to the nominal interest rate equal unity. One can write total consumption as

$$c(s,t) = (\alpha + \beta) (n(s,t) + h(s,t)) \quad (2.6)$$

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

$$h(s,t) \equiv \int_t^\infty (w(v) l(s,v) + \pi(s,v) - z(s,v)) \exp(-\int_t^v (r(\mu) + \beta) d\mu) dv. \quad (2.7)$$

Human wealth is the discounted stream of after-tax income, where the discount rate is augmented with the probability of death in order to allow for the fact that individuals only earn income when they are alive. The consumption function is linear in human plus non-human wealth, because the intertemporal elasticity of substitution is assumed to be unity. This assumption facilitates the aggregation across individuals born at the same instant. (Blanchard (1985) discusses the implications of general iso/elastic utility functions for non-monetary economies.)

2.2. Aggregation across individuals

The aggregation procedure for families of finitely-lived agents due to Yaari (1965) and Blanchard (1985) will be applied. At each instant t a new cohort of size β is born. Since β is also the probability of death, the size at time t of the surviving cohort born at time $s \leq t$ equals $\beta \exp(-\beta(s-t))$ and therefore the total population at time t equals $\int_t^\infty \beta \exp(-\beta(s-t)) ds = 1$. The population aggregate for, say, total consumption is obtained as the sum of the total consumption of all surviving cohorts at time t times the size of the surviving cohort, so that it is defined as

$$C(t) \equiv \beta \int_{-\infty}^t c(s,t) \exp(\beta(s-t)) ds. \quad (2.8)$$

Other population aggregates are obtained in a similar fashion and are also denoted by a capital letter.

Application of this aggregation procedure yields $C_d = \gamma_1 C$, $C_m = \gamma_2 C/v$, $M = \gamma_3 C/i$,

$$dC(t)/dt = (r(t) - \alpha) C(t) - \beta(\alpha + \beta) N(t) \quad (2.9)$$

and

$$dN(t)/dt = r(t) N(t) + w(t) L(t) + \Pi(t) - Z(t) - C(t). \quad (2.10)$$

The derivation of (2.10) made use of the fact that, in the absence of bequests, the non-human wealth of newly born individuals must be zero, $n(t,t) = 0$. Unlike (2.2), (2.10) does not contain a life insurance premium as this corresponds to a transfer from those who die to those who survive and therefore this does not affect the return on aggregate non-human wealth. Aggregation of human wealth gives $dH/dt = (r+\beta)H - wL - \Pi + Z$. Substitution of this and the aggregate consumption function, $C = (\alpha+\beta)(N+H)$, into (2.10) yields (2.9).

2.3. Financial assets and the government budget constraint

The asset menu of consumers consists of real home government bonds, real foreign government bonds and home cash. Non-human wealth corresponds to $N \equiv M + B$, where B denotes holdings of home and foreign government bonds by home individuals. The government services its debt, spends on home and foreign goods, levies lump-sum taxes and finances the resulting deficit by printing money or by borrowing. This is captured by the government budget constraint:

$$dD(t)/dt = r(t)D(t) + G(t) - Z(t) - \theta M(t), \quad D(0) = D_0, \quad (2.11)$$

where D denotes the government debt issued to home and foreign individuals, $G \equiv G_d + vG_m$ denotes total exhaustive government spending and θ denotes the exogenous growth rate of the aggregate nominal supply of outside money. Integration of (2.11) and the solvency (no Ponzi games) condition gives

$$D(t) = \int_t^\infty (Z(v) + \theta M(v) - G(v)) \exp(-\int_t^v r(\mu) d\mu) dv, \quad (2.11')$$

so that the current real government debt plus the present discounted value of future government spending has to be paid off by the present discounted value of future lump-sum and inflation taxes. Note that the assumption of finite lives 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 wedge is the main reason why the Ricardian debt neutrality proposition does not hold, so that the burden of higher taxation can be passed on to future generations.

Equilibrium in the money market is given by

$$dM(t)/dt = (\theta - p(t)) M(t), \quad m(0) = \text{free}, \quad (2.12)$$

where the initial price level and the initial holdings of real money balances depend on expected future events and are therefore unconstrained by their past history.

It is assumed that the government has Cobb-Douglas preferences over home and foreign goods, so that $G_d = (1-\gamma') G$ and $G_m = \gamma' G/v$ where γ' is the share of imports in total government spending. Feedback rules for taxation, government spending or monetary growth are required, because in the absence of such rules the solvency of the government's finances is not guaranteed and therefore the government debt explodes. A sensible tax rule (Buiter, 1987a) is

$$Z(t) = Z_0 + \xi_1 D(t) - \xi_2 (dD(t)/dt), \quad \xi_1, \quad \xi_2 \geq 0, \quad (2.13)$$

and a similar rule for government spending is

$$G(t) = G_0 - \xi_3 D(t) + \xi_4 (dD(t)/dt), \quad \xi_3, \quad \xi_4 \geq 0. \quad (2.14)$$

Upon substitution into the government budget constraint (2.11), one has

$$dD(t)/dt = \xi \{ (r(t) - \xi_1 - \xi_3) D(t) + G_0 - Z_0 - \theta M(t) \}, \quad (2.15)$$

where $\xi \equiv 1/(1-\xi_2-\xi_4)$. To ensure the solvency of the government's finances, it is assumed either that $\xi_1 + \xi_3 > r$ and $\xi_2 = \xi_4 = 0$ ($\xi=1$) or that $\xi_1 = \xi_3 = 0$ and $\xi_2 + \xi_4 > 1$ ($\xi < 0$). The first possibility is discussed at length in Section 4. The second possibility is discussed in Section 3. Under the second possibility a long-run increase in taxation leads in the short run to government surpluses and is therefore preceded by short-run cuts in taxation and increases in government spending. The government has four policy

instruments, viz., G_0 , Z_0 , θ and D , of which the first three can be chosen independently and the fourth one follows residually from the government budget constraint.

2.4. Production, labour demand and wage rigidity

Firms produce at home under perfect competition and maximise profits subject to a concave and twice-differentiable production function, $Y = f(L)$, $f' > 0$, $f'' < 0$ where Y denotes aggregate production and L denotes aggregate employment. Hence, the marginal product of labour equals the real wage and labour demand and aggregate supply are decreasing functions of the real wage, $L = L(w)$, $L' = 1/f'' < 0$ and $Y = Y(w)$, $Y' = f'/f'' < 0$. For simplicity, a Cobb-Douglas production function, say $f(L) = \rho_0 L^\rho$, $0 < \rho < 1$, is assumed, so that $L(w) = (\rho_0 \rho / w)^{1/(1-\rho)}$, $Y(w) = \rho_0 (\rho_0 \rho / w)^\rho / (1-\rho)$ and $wL/Y = \rho$.

It is assumed that either real or nominal wages are rigid and are above the market-clearing level, so that individuals are rationed in their supply of labour. This means that their actual supply of labour is given by the demand for labour and should affect their human wealth and consumption rather than the notional supply of labour. Obviously, this spill-over of labour market disequilibrium into the goods market implies that consumption will be less than if individuals are not rationed. There is a reasonable amount of empirical evidence that Europe and Japan are characterised by real wage rigidity whilst the US and Canada are characterised by nominal wage rigidity (e.g., Branson and Rotemberg, 1980; Bruno and Sachs, 1985; van der Ploeg, 1987b). These stylistic facts will be taken account of. Hence, the home country corresponds to Europe and Japan and has real wage rigidity,

$$P(t) w(t) / P_c(t) = \omega_0 L^\omega, \quad \omega_0, \omega \geq 0, \quad (2.16)$$

where P_c denotes the consumers' ideal price index. Layard and Nickell (1986) provide some empirical evidence for wage bargaining equations of this type. If the opportunity costs of holding real money balances are ignored, the ideal cost-of-living index associated with the utility function (2.1) is an average of home and foreign prices:

$$P_C = P v^{\gamma_2} i^{\gamma_3} \equiv P v^{\gamma}, \quad \gamma \equiv \gamma_2/(\gamma_1 + \gamma_2) \quad (2.17)$$

Upon substitution of (2.16) and (2.17) into $Y(w)$, one obtains aggregate supply of the home country:

$$Y = \rho_0((\omega_0/\rho_0\rho) v^{\gamma})^{-\rho/(1-\rho+\omega)} \equiv \hat{Y}(v). \quad (2.18)$$

Hence, an appreciation of the real exchange rate reduces the relative price of imports, cuts the wedge between the consumers' and producers' wage and therefore boosts aggregate supply. The foreign country corresponds to the US and Canada and has nominal wage rigidity,

$$p^*(t) + w^*(t) = \psi^* \log(u_n^*/(1-L^*(t))) + \theta^* \quad (2.19)$$

where foreign variables are denoted by an asterisk, u_n^* denotes the natural rate of unemployment, and $w^*(t) \equiv (dw^*(t)/dt)/w^*(t)$ denotes the growth rate of the foreign real wage. Core inflation in the foreign country is given by long-run inflation, that is the exogenous growth in the nominal money supply (cf., Buiter and Miller, 1982). The difference in the nature of the labour market disequilibrium is the main asymmetry in this two-country model.

2.5. International interdependence

The world consists of two economies with identical preferences, technologies and demographic structures. The foreign country has similar relationships to the ones discussed in Sections 2.1-2.4 (except for (2.16) and (2.18)) and its variables are denoted by an asterisk. There is no labour mobility between the two countries and there is no currency substitution. There is perfect substitution and risk-neutral arbitrage between home and foreign government bonds, which results in uncovered interest parity:

$$i(t) = i^*(t) + E\{(dE(t)/dt)/E(t)\} \quad (2.20)$$

where E denotes the nominal exchange rate and $E\{.\}$ denotes the expectations operator. Alternatively, $r(t) = r^*(t) + E\{(dv(t)/dt)/v(t)\}$, where $v \equiv P^*E/P$, must hold. There is imperfect substitution between home and foreign goods and each country is wholly

specialised in the production of its exportable. The condition for equilibrium in the home goods market is given by

$$Y = C_d + G_d + C_m^* + G_m^* \quad (2.21)$$

and the one for the foreign goods market is given by

$$Y^* = C_d^* + G_d^* + C_m + G_m. \quad (2.22)$$

Net holdings of foreign assets are the excess of private sector agents' holdings of bonds over government debt, that is $F \equiv B - D$. Equilibrium in the world bonds market gives $B + vB^* = D + vD^*$, which implies $F^* = -F/v$. The current account consists of interest payments on net foreign assets plus the balance of trade and equals the increase in wealth of the nation:

$$\begin{aligned} dF(t)/dt = & r(t)F(t) + C_m^*(t) + G_m^*(t) - \\ & v(t)(C_m(t) + G_m(t)). \end{aligned} \quad (2.23)$$

An alternative expression for the balance of trade gives it as the excess of domestic production over domestic absorptions, that is $Y - C_d - vC_m - G$. Note that (2.23) follows from subtraction of (2.11) and (2.12) from (2.10). Integration of (2.23) and application of the country's solvency condition gives the country's intertemporal budget constraint:

$$\begin{aligned} -F(t) = & \int_t^\infty (Y(v) - C_d(v) - v(v)C_m(v) - G(v)) \\ & \exp(-\int_t^v r(\mu)d\mu) dv \end{aligned} \quad (2.23')$$

which says that the current debt of the nation eventually has to be paid off by future savings' surplusses of the government and private sector (i.e., by future balance-of-trade surplusses). There will be jumps in the initial value of the real exchange rate, $v(0)$, and therefore in the initial level of foreign assets. The model is not complete until a rule for where bonds are held initially is specified. For example, if all goods are denominated in the foreign (home) country's goods then F (F^*) is predetermined. To simplify matters, it

will be assumed that initially neither country holds any foreign assets and therefore $F(0) = 0$.

2.6. The complete model

The complete two-country model can be summarised by ten equations:

$$dC/dt = (r-\alpha) C - \beta(\alpha+\beta) (M+D+F), \quad C(0) = \text{free} \quad (2.24)$$

$$dC^*/dt = \{r - [(dv/dt)/v] - \alpha\} C^* - \beta(\alpha+\beta) (M^*+D^* - (F/v)), \\ C^*(0) = \text{free} \quad (2.25)$$

$$dM/dt = (r+\theta) M - \gamma_3 C, \quad M(0) = \text{free} \quad (2.26)$$

$$dM^*/dt = \{r - [(dv/dt)/v] + \theta^*\} M^* - \gamma_3 C^*, \quad M^*(0) = \text{free} \quad (2.27)$$

$$dD/dt = \xi\{(r-\xi_1-\xi_2) D + G_0 - Z_0 - \theta M\}, \quad D(0) = D_0 \quad (2.28)$$

$$dD^*/dt = \xi\{(r - [(dv/dt)/v] - \xi_1 - \xi_2) D^* + G_0^* - Z_0^* - \theta^* M^*\}, \\ D^*(0) = D_0^* \quad (2.29)$$

$$dF/dt = rF + \gamma_2(vC^*-C) + \gamma'(vG_0^*-G_0) + \gamma'v\{-\xi_3 D^* + \\ \xi_4 \xi\{(r - [(dv/dt)/dv] - \xi_1 - \xi_2) D^* + G_0^* - Z_0^* - \theta^* M^*\}\} - \\ \gamma'(-\xi_3 D + \xi_4 \xi\{(r-\xi_1-\xi_2) D + G_0 - Z_0 - \theta M\}), \quad F(0)=0 \quad (2.30)$$

$$dX^*/dt = \psi^* \log\{u_n^*/[1-L(X^*M^*)]\} X^*, \quad X^*(0) = X_0^* \quad (2.31)$$

$$\hat{Y}(v) = \gamma_1 C + (1-\gamma')G_0 + \gamma_2 vC^* + \gamma'vG^* + (1-\gamma') \\ \{-\xi_3 D + \xi_4 \xi\{(r-\xi_1-\xi_2) D + G_0 - Z_0 - \theta M\}\} \quad (2.32)$$

$$Y(X^*M^*) = \gamma_1 C^* + (1-\gamma')G_0^* + \gamma_2 (C/v) + \gamma' (G/v) + (1-\gamma') \\ \{-\xi_3 D^* + \xi_4 \xi\{(r - [(dv/dt)/v] - \xi_1 - \xi_2) D^* + G_0^* - \\ Z_0^* - \theta^* M^*\}\} \quad (2.33)$$

where $X^* \equiv W^*/M^*$ denotes the foreign wage normalised by the foreign money supply. The goods market equilibrium conditions, (2.32)-(2.33), can be solved for v , dv/dt and r in terms of the state-space

variables, viz., $C, C^*, M, M^*, D, D^*, F$ and X^* , and the policy instruments, viz., $G_0, G_0^*, Z_0, Z_0^*, \theta$ and θ^* . The state-space variables can then be solved from (2.24)-(2.31) in terms of the policy instruments. Note that the distribution of taxes and government spending across generations does not affect aggregate outcomes.

3. Steady-state properties

In the long run inflation is entirely determined by monetary growth, so that $p = p_c = \theta$ and $p^* = p_c^* = \theta^*$. The rate of depreciation of the home country's nominal exchange rate equals the difference between home and foreign monetary growth, $(dE/dt)/E = \theta - \theta^*$, so that in the long run relative purchasing power parity holds. In the country with nominal wage rigidity unemployment and output are in the long run at their natural rates, $1 - L^* = u_n^*$ and $Y^* = f(1 - u_n^*)$. In the country with real wage rigidity long-run employment and output depend on the wedge between the real producers' and consumers' wage and therefore depend on the long-run real exchange rate, i.e., $L = f^{-1}(\hat{Y}(v))$ and $Y = \hat{Y}(v)$, so that aggregate demand can affect long-run activity in the home country. The long-run real exchange rate follows together with the long-run real interest rate from the equilibrium conditions for the home and foreign goods markets. Before this can be discussed, it is necessary to derive the expressions for the long-run levels of total consumption. This will be done for the case $\xi_1 = \xi_3 = 0$, so that $G(\infty) = G_0$ and $Z(\infty) = Z_0$.

Long-run non-human wealth follows from (2.10) and (2.13) and is the annuity value of private dissaving, $N = -(f(L) - Z_0 - C)/r$, whilst human wealth is the discounted sum of after-tax income, $H = [f(L) - Z_0]/(r + \beta)$, so that total consumption is given by

$$C = (\alpha + \beta) (N + H) = \beta(\alpha + \beta) [f(L) - Z_0] / [(r + \beta)(\alpha + \beta - r)]. \quad (3.1)$$

It is assumed that $\alpha < r(\infty) < \alpha + \beta$ holds. Hence, consumption and total wealth are increasing functions of income and the real interest rate and decreasing functions of taxes. Taxes affect total consumption, because lives are finite ($\beta > 0$) and therefore the Ricardian debt neutrality proposition does not hold. An increase in

taxation means that the private sector has less human wealth. Also, the government can afford to service a larger government debt and, with finite lives government debt is part of private sector non-human wealth, the private sector has more non-human wealth. However, the fall in human wealth dominates the increase in non-human wealth and therefore on balance consumption falls. An increase in the probability of death makes individuals more impatient and increases their consumption, but it also cuts their human wealth and therefore consumption. On balance consumption decreases in the long run ($\partial C / \partial \beta = -r(N+H((r-\alpha)/(r+\beta)))/(\alpha+\beta-r) < 0$).

Upon substitution of (3.1) and (2.28) into (2.32), one obtains the home goods market equilibrium (GME) locus,

$$(r+\beta)(\alpha+\beta-r) (Y-(1-\gamma')G_0 - \gamma'vG_0^*) = \beta(\alpha+\beta)(\gamma_1 Y + \gamma_2 vY^*) - (\gamma_1 Z_0 + \gamma_2 vZ_0^*), \quad (3.2)$$

and a symmetric expression for equilibrium in the foreign goods market can be obtained from (2.33). Aggregate supply at home is a decreasing function of the real exchange rate, $Y = Y(v)$, so that the AS schedule slopes downwards (see Fig. 1). A depreciation of the real exchange rate boosts foreign demand for home goods and cuts aggregate supply of home goods; the resulting excess demand for home goods is choked off by the fall in home and foreign demand for home goods induced by the fall in the world real interest rate. Hence, the GME locus slopes downwards in v - r space (see Fig. 1). The above argument assumes that the indirect effect of an increase in income on aggregate demand is less than the direct effect on aggregate supply (i.e., $\gamma_1 \beta(\alpha+\beta) < (r+\beta)(\alpha+\beta-r)$). Foreign aggregate supply is fixed, $Y^* = f(1-u_n^*)$, so that the upward-sloping GME* locus is steeper than it would have been under real wage rigidity. It follows from Fig. 1 that the long-run real exchange rate and interest rate can be written as:

$$v = V(G_0, G_0^*, Z_0, Z_0^*, \omega_0, u_n^*) \quad (3.3)$$

$$r = R(G_0, G_0^*, Z_0, Z_0^*, \omega_0, u_n^*) \quad (3.4)$$

where the signs of the partial derivatives are given below the expressions and are evaluated on the assumption that there is a domestic bias in demand, that is $\gamma_1 > \gamma_2$ and $\gamma' < \frac{1}{2}$. An increase in foreign government spending (or a decrease in foreign taxation) shifts out the GME* locus by more than the GME locus, so that the home country's real exchange rate depreciates, the wedge between the home producers' and consumers' wage increases, and home output falls (see Fig. 1). The incipient excess demand for home goods, arising from the boost in the home country's net exports and fall in home supply, is choked off by a fall in consumption which is induced by a fall in the real interest rate and a fall in income. Foreign consumption falls by a smaller amount. An increase in home government spending (or a decrease in home taxation) leads to a fall in the real interest rate, an appreciation of the real exchange rate and a boost of home aggregate supply. It is clear that an increase in government spending (or a decrease in taxation) crowds out private consumption, because it cuts the world real interest rate. For home private consumption there is an additional effect, because a home (foreign) fiscal expansion also leads to an appreciation (depreciation) of the real exchange rate and therefore to an increase (fall) in home output, income and consumption. Note that a fiscal expansion cuts the real interest rate in the long run, since here it is assumed to be financed by taxes. When it is financed by bonds, the real interest rate will rise in the long run (see Section 4.1).

An increase in the home real consumers' wage, w_0 , reduces home output and income, which reduces the demand for home and foreign goods. Hence, both the GME and the GME* locus shift down. It follows that the real exchange rate appreciates, which attenuates the fall in home output, whilst the effect on the real interest rate is ambiguous. An increase in the foreign country's natural unemployment rate shifts up both the GME and the GME* locus, so that the relative price of foreign goods increases and the effect on the interest rate is ambiguous. Clearly, the increase in the home wedge means that home output also falls. Changes in monetary growth, at home or abroad, have no long-run effects on the real interest rate, the real exchange rate, output or employment. However, when allowance is made for capital accumulation such effects will occur (Marini and van der Ploeg, 1987).

4. Dynamic policy simulation

Table 1 presents the parameter values, values taken on by the exogenous variables and initial conditions used in the numerical simulations. The solution is obtained with the aid of a multiple shooting algorithm (Lipton, et al., 1982). Table 1 also presents the eigenvalues evaluated at the steady state. It is clear from these that the system satisfies the saddlepoint property of perfect-foresight systems, since there are four unstable eigenvalues associated with the jump variables C , C^* , M and M^* and four stable eigenvalues associated with the predetermined variables D , D^* , F and X^* . There is one negative eigenvalue with a very small magnitude, -0.016404 , which corresponds to extremely sluggish adjustment and which is mainly associated with the dynamics of the current account. This mode takes about 280 periods to settle down to within 1% of its equilibrium value $(-\ln(0.01)/0.016404)$ whilst the others take only about 10 periods.

4.1. Tight fiscal policy in Europe and loose fiscal policy in the US

To study the effects of fiscal expansion in the US and fiscal contraction in Europe at the same time, it helps to first look at the impact of both policy shocks in isolation. Table 2a presents the results of an increase in European government spending from $G=0.1$ to $G=0.15$. Expressed in terms of initial GNP the increase amounts to 5.4%. Table 2b presents the results for the same increase in US government spending, G^* . The figures correspond to percentage deviations from the initial steady-state values, except for r , r^* and F which are deviations from the initial steady-state values times 100. Tax rules have been used to stabilise the government debt ($\xi_1=0.5$, $\xi_3=0.0$).

An unanticipated, permanent fiscal expansion in Europe induces on impact an excess demand for home goods, which raises prices and depresses real money balances. The real exchange rate appreciates, boosting imports of foreign goods and depressing exports of home goods. Private consumption is crowded out, but the increase in domestic output mitigates this effect. The appreciation of the real exchange rate drives a wedge between the producers' and consumers'

real wage. The real producers' wage (w) falls leading to an increase in employment and output. The rise in imports from the US to Europe causes a small price increase in the US. This implies a fall in real producers' wages as nominal wages in the US are rigid in the short run. Consequently, US employment and output increase showing that fiscal expansion in Europe has a locomotive effect. The locomotive effect in our example is relatively small, but note that the effect depends on the demand elasticities which are fairly low in our example. Private consumption in the US declines due to a deterioration of the terms of trade. This is manifested most clearly in the fall of imports.

Although on impact the real interest rate falls in both Europe and the US by 0.017% and 0.038%, respectively, the nominal interest rate rises on impact by 0.026% in Europe and by 0.003% in the US. The reason is that inflation rises on impact by 0.043% in Europe and by 0.041% in the US. The associated crowding out of private consumption on impact occurs through falls in holdings of real money balances, since holdings of bonds do not change on impact and human wealth increases on impact.

In the medium run government debt in Europe rises fast and the balance of payments shows increasing deficits leading to an accumulation of foreign debt. The US benefits from increasing interest receipts on foreign assets. The long-run solutions reflect these developments. Private consumption in the US has now increased and the fall in imports from Europe (C_m^*) is mitigated. As for Europe, private consumption falls even further and imports from the US (C_m) eventually change sign because of the increased burden of foreign interest payments. In the long run employment in Europe remains above its initial level as a result of the wedge between the producers' and consumers' real wage. In the US nominal wage flexibility induces equilibrium in the labour market over time.

Table 2b presents the results for an unanticipated fiscal expansion in the US. On impact prices in the US rise and the real producers' wage falls. Output and employment increase substantially. There is still some crowding out of private consumption but it is relatively small. The terms of trade improves for the US. As a result

Europe is confronted with a depreciation of its real exchange rate and an increase in its relative consumers' price index. With real wage rigidity nominal wages increase and producers' prices fall behind. The increase in real wages induces unemployment and a fall in output, so that fiscal expansion in the US is a beggar-thy-neighbour policy. Private consumption in Europe declines too, which accentuates the decline in imports from the US induced by the increase in the relative price of US goods.

In the medium run the US runs a deficit on the current account of the balance of payments and foreign debt is accumulated. Interest payments now go from the US to Europe. Meanwhile equilibrium in the US labour market is restored. Output declines and the excess demand for domestic goods induces further price increases. Crowding out of private consumption continues over time and is reinforced by the interest payments on foreign debt. Europe becomes worse off as time passes, because its real exchange rate depreciates further. The unhappy results in the short run are therefore magnified in the long run. The stream of interest payments from the US may weaken the process, but the trend is not fully reversed as can be seen from the last two columns of Table 2b. In the long run unemployment in Europe remains at a high level. Hence, when Europe has real wage rigidity, a favourable demand shock in the US leads to an increase in the NAIRU of Europe, as observed in Section. 3.

Note that the real exchange rate overshoots its long-run value for a European fiscal expansion whilst it undershoots for a US fiscal expansion. In the absence of international policy coordination US fiscal policy may be too loose if the US authorities ignore the adverse effects of fiscal expansion on the European economy. This conclusion holds for the short and medium run. In the long run the adverse effects of US fiscal policy are somewhat mitigated by the positive influence on the European economy of foreign interest receipts. It may be argued that fiscal policy in Europe is in turn too tight, because the beneficial effects on the US economy are not taken into account. However, such a conclusion demands a careful interpretation. In the short run there is a positive effect on output and employment, but consumption and welfare decline. The negative terms-of-trade effect dominates the output effect in the short run. In

the long run equilibrium in the labour market is restored and the output effect vanishes. But then the positive effect of foreign interest receipts outweighs the negative terms-of-trade effect and consumption increases. The conclusion that European fiscal policy is in the absence of international policy coordination too tight must therefore be qualified.

4.2. 'Reaganomics': Tax cuts precede cuts in government spending

Table 3a presents the effects of an autonomous reduction in US tax receipts ($\Delta Z_0^* = -0.4$) when the variable component of the tax rule ($\xi_1 = 0.5$, $\xi_3 = 0$) is used to stabilise the government debt. The impact effects on the US are plausible. Lowering taxes induces inflation and crowding in of private consumption. Inflation in the US implies a decline in the US real producers' wage, because nominal wages in the US are rigid in the short run. Output and employment increase as the real wage falls, so that tax cuts in the US have favourable short-run effects on its economy. The US real exchange rate appreciates. The associated depreciation of the real exchange rate in Europe increases the wedge between the producers' and consumers' real wage. As a consequence the real producers' wage rises which leads to a fall in European output and employment. This development is reflected in the lower level of private consumption in Europe. In this sense the result resembles the fiscal policy variant presented in Table 2b.

The dynamic effects are substantial. Government debt in the US rises fast. (The high figures for the percentage deviations are of course related to a low level of D^* in the initial steady state.) The increase in government debt calls for a gradual rise in taxes to stabilise the economy. Table 3a shows that the level of taxes increases, but that the absolute deviations (ΔZ^*) become smaller as time proceeds. The rise in taxes stabilises the economy but the US runs a deficit on the current account of the balance of payments, which leads to an accumulation of foreign debt. The burden of foreign debt weighs heavily on the US economy, because of the interest payments flowing from the US to Europe. In the long run this has dramatic effects. Unlike the case of fiscal policy (Table 2b) Europe becomes more of a rentier economy in the sense that it benefits from

the original tax cut in the US. The signs of the relevant variables, i.e., terms of trade, consumption in both countries, and production and employment in Europe, eventually reverse. The real exchange rate of the US starts depreciating at $t=4$ and the terms of trade falls below the initial steady-state value at $t=18$. The depreciation of the US real exchange rate reflects the fact that ultimately the interest payments on foreign debt have to be paid by running a surplus on the trade balance.

Although the system with a tax rule tends towards a new steady state and is therefore stable, the political economy of the US under Mr. Reagan suggests that cuts in US taxation gradually lead to increases in US government debt and only then to cuts in government spending (cf., Blanchard, 1987). The political economy of fiscal deflation in the US is such that a rule for government spending to ensure the solvency of the government's finances is, perhaps, more realistic than a tax rule. Hence, Table 3b presents the effects of a previously unanticipated, permanent cut in US taxes ($\Delta Z^* = \Delta Z_0^* = -0.2$ at $t=0$) when the government spending rule is given by (2.13) with $\xi_3=0.1$ and $\xi_4=0.0$. As before, the impact effects on output and employment are positive for the US and negative for Europe. They are much larger in magnitude than for the tax cut presented in Table 3a, despite the fact that it corresponds to only half the reduction in taxes. The reason is that people anticipate future reductions in government spending instead of future increases in taxes, so that human wealth does not fall as much and therefore consumption today will be higher than in Table 3a. On impact there will be a price increase in the US leading to a fall in real producers' wages and an increase in US employment and output. As a result private consumption of domestic and foreign goods rises. The US real exchange rate appreciates, which leads to a fall in exports and an increase in the volume of imports. The depreciation of the European real exchange rate increases the wedge and induces a fall in employment and output. Private consumption falls by even more to create room for a rise in exports from Europe to the US. The price of domestic goods rises in Europe, which is necessary to crowd out private consumers' spending.

The dynamic effects show a steady increase in US government debt and a gradual rise in the deficit on the current account. With a low

value for ξ_3 it takes a long time to stabilise the economy, which is reflected in the long-run equilibrium values of the model. For example, if $\xi_3=0.5$ instead of 0.1, the steady-state value of the US foreign debt is 18.89 instead of 204.48 and as a result the required long-run depreciation of the US real exchange rate, in order to generate the long-run trade surplus necessary to finance the servicing of the foreign debt, is only 12.57 rather than 29.32 (see Table 3c).

However, the medium-term results merit some closer attention. The reduction in government spending at $t=1$ is substantial, because its deflationary impact leads to a reversal of signs with respect to employment and output. Whereas output and employment decrease, crowding-in allows a rise in consumers' expenditure. This is the typical pattern for the US economy. The government has to cut expenditure along the adjustment path. This leads to a recession with output and employment declining for a protracted period of time (the lowest point is attained at $t=9$). However, private consumption flourishes when the government steps back gradually. The US real exchange rate depreciates as the deflationary effects of a reduction in government spending dominate the scene. This has a favourable impact on the European economy. Unemployment in Europe declines and from $t=3$ onwards there is a situation of overemployment. Output and employment rise along the adjustment path. The depreciation of the US real exchange rate is reinforced in the course of time as interest payments to Europe rise together with the increase in foreign debt.

In the long run there is equilibrium on the US balance of payments, but the US emerges as a strong debtor country. The exports from the US to Europe show a dramatic rise, while US imports even decline. It should be noted that these effects are mitigated if ξ_3 is higher. For instance, with $\xi_3=0.5$ the recession following a cut in taxes is deeper and shorter. The lowest point in employment is now attained at $t=3$. As a result stabilisation of the US economy requires ultimately a reduction in government expenditure which is less than half the value of the cut in government expenditure when $\xi_3=0.1$. The deeper recession also has a relatively favourable effect on the balance of payments. In the new steady state the increase in the foreign deficit amounts to 18.9 (see Table 3c) which has to be

compared with the rise of 204.5 in Table 3b. It follows that 'Reaganomics' should be strong to avoid adverse long-run effects on the balance of payments. A powerful recession is needed to control the crowding-in of private consumption.

4.3. Unpleasant monetarist arithmetic

A policy of tight money without a tax rule or an expenditure rule ($\xi_1 = \xi_3 = 0.0$) to guarantee the solvency of the government's finances will lead to an excessive growth of government debt. At a certain point in time agents may refuse to absorb additional government bonds. To finance the deficit after this ceiling has been attained the monetary authorities will have to opt for an increase in monetary growth, that is a policy of 'easy' money. The alternative of increasing taxes is not considered, because the issue here is to what extent the monetary authority can fight inflation if it is not in a position to make a structural fiscal adjustment. In other words, macroeconomic coordination implies that fiscal authorities 'move' first. Sargent and Wallace (1981) have shown that such a policy of tight money now and loose money later may result in a higher rate of inflation now, because agents anticipate what is going to happen in the future. In this section the effects of a policy switch from tight money now towards loose money later in the US are discussed. For convenience, it is assumed that in Europe the government budget is balanced all the time by adjusting taxes.

To improve our understanding of the policy switch a comparison will be made with a policy of tight money in the US under a tax rule ($\xi_1 = 0.5$, $\xi_2 = 0$) operating in both countries to stabilise the economy. In this example macroeconomic policy coordination implies that monetary authorities 'move' first. The effects of this benchmark view are presented in Table 4a. It is assumed that the US monetary growth rate is reduced by 0.5 percentage points. A monetary disinflation leads on impact to a fall in the price of domestic goods in the US. Since there is nominal wage rigidity in the US, the real producers' wage rises and output and employment decline. Consumption of domestic goods and imports fall too, but the balance is shifted towards foreign goods as the real exchange rate appreciates. The corresponding

depreciation of the European real exchange rate increases the wedge between the producers' and the consumers' wage, which results in unemployment and a fall in output. As a consequence consumption in Europe falls as well.

Inflation initially overshoots by 1.31% and subsequently there is a gradual adaption of the inflation rate towards the monetary growth rate in the US. As a result the negative volume effects are to a large extent reversed. The increase in taxes stabilises government debt in both countries. In the long run there are minor changes in consumption as a result of opposing changes in the components of real wealth. In the US non-human wealth increases, but human wealth decreases by a larger amount. In Europe the situation is the other way around, because foreign assets are accumulated in line with the depreciation of the real exchange rate.

Note that with a monetary disinflation the real exchange rate misadjusts rather than overshoots as in the famous Dornbusch (1976) model. The reason is that a monetary disinflation in the US means that the US becomes a debtor nation and requires a long-run trade surplus to finance the interest payments to Europe, which in turn requires a long-run depreciation of the US real exchange rate. It follows that a US monetary disinflation is a beggar-thy-neighbour policy in the short run, but a locomotive policy in the long run.

The effects of tight money now and loose money later in the US are presented in Table 4b. It is assumed that there is a ceiling on the amount of government debt, which is attained at $t=11$. The maximum increase of debt amounts to about 16%. Before the ceiling is hit ($t=0, 1, \dots, 10$) monetary growth is reduced by 0.5 percentage points. At $t=11$ the ceiling on US government debt is hit, $D^* = 16.046$, and from then onwards the growth rate of money is determined endogenously in such a way that the government budget is balanced. To realise a balanced budget the monetary growth rate has to be increased (see Table 4b). Ultimately θ^* and p^* rise by more than one percentage point, so that tight money in the interim period implies a permanently higher rate of inflation. The reason for this is that the US government now has to service a larger debt (cf., van Wijnbergen, 1985).

On impact of the monetary disinflation there is a relatively small reduction in the price of domestic goods in the US, compared with the outcome in Table 4a. Real wages rise somewhat and output, consumption and employment decline. However, the development is already reversed in period $t=1$. The reduction in nominal wages caused by an excess supply of labour exceeds the fall in prices, so that employment and the other real variables increase. The decline in the rate of inflation is moderate and stays behind the reduction in the growth rate of the money stock. Inflation rises in the course of time and at $t=4$, long before the ceiling is hit, the rate of inflation is even higher than in the initial steady state. This result confirms the finding of Sargent and Wallace that tight money now may go hand in hand with a higher rate of inflation now if agents fully anticipate the corrective measures to be taken later when the private sector refuses to absorb an increasing amount of government bonds. The results for Europe as an economy run parallel with those in the US. The European real exchange rate first depreciates and then appreciates, which leads to a reversal in the signs of all real variables.

In the long run there are no effects on real variables. Inflation increases in the US but does not change in Europe. Non-human wealth in the US is constant, because the increase in real government debt is exactly matched by a decline in real cash balances. Money is neutral in the long run. Long-run changes, as observed in Table 4a, come from a change in the tax level, which influences human as well as non-human wealth in a model with finite lives as shown in Section 3. As discussed above, taxes are held constant in the Sargent-Wallace exercise discussed above.

4.4. Supply-side policies

Supply-side policies in Europe can be interpreted as measures to reduce real wages. Table 5a presents the results of measures taken to reduce the initial steady-state real consumers' wage (ω_0) by five percent. A wage reduction leads to an increase in employment and output. As a result the European terms of trade declines and part of the initial fall in real wages is reversed as workers have to be

compensated for higher import prices. Hence, the real producers' wage falls by only 2.75%. The increase in output induces a rise in consumption of domestic goods, whereas the unfavourable development in the terms of trade leads to a decline in imports. The impact on the US economy is small except for US imports from Europe which increase substantially as European goods become relatively cheaper.

The dynamic effects are moderate and the long-run solution differs only slightly from the short-run result. Europe accumulates foreign assets in small amounts. Ultimately, the US has to pay interest on its foreign debt which is reflected in a somewhat lower level of imports in the long run. The other side of the coin is that consumption in Europe gains from the accruing interest payments. In the long run imports from the US even increase.

Supply-side policies in the US are directed at reductions in the natural rate of unemployment. The effects of a reduction in u_n^* by five percentage points are presented in Table 5b. It is assumed that the reduction is brought about in the initial period, which makes the interpretation of the results somewhat easier. A fall in the NAIRU leads to a decline in nominal wages after a lag. On impact of the supply shock changes are small except for the real rate of interest which has to increase in both countries to choke off consumption in anticipation of better times. Over the adjustment period nominal and real wages in the US decline whilst employment and output gradually increase. Nominal prices decrease to absorb the additional output and the terms of trade deteriorates. For Europe this means an improvement in the terms of trade leading to a decrease in the cost of living. Hence, nominal and real wages decline which results in a rise of employment and output.

The situation applies to the medium run, from $t=1$ to $t=10$. Labour market adjustment in the US leads to higher employment and output which spills over to Europe. Around $t=10$ the adjustment in the labour market is nearly completed. Employment increases by 5.5%, which is consistent with a fall in the natural rate of unemployment from 10% to 5%. The long-run results are practically indistinguishable from the outcomes at $t=10$. Accumulation of foreign assets by the US

economy occurs at a low rate and the associated interest payments are therefore negligible.

It follows that supply-side policies in Europe increase welfare in the US. The US terms of trade improves, which raises imports without affecting the consumption of domestic goods very much. For the US there are almost no output and employment effects. However, supply-side policies in the US increase employment and output in both the US and Europe. The terms of trade moves against the US and the wedge between the producers' and consumers' real wage in Europe declines.

5. Concluding remarks

A two-country, perfect-foresight model with micro foundations, finite lives, intertemporal budget constraints for the two governments and private sector agents, current-account dynamics, uncovered interest parity, floating exchange rates, imperfect substitution between home and foreign goods, international labour immobility, real wage rigidity at home (Europe) and nominal wage rigidity abroad (US) has been formulated and its steady-state and transient properties have been analysed. In order to relax the Ricardian debt neutrality proposition and to give a non-trivial role for fiscal policy, it has been assumed that there is no intergenerational bequest motive and lives are finite so that the burden of higher taxation can be passed on to future generations. This also allows a richer form of current-account dynamics. Unemployment has been the main problem of the OECD economies in the eighties, so it has been assumed that wages are inflexible. In view of recent empirical evidence, it has been assumed that there is nominal wage rigidity in the US and real wage rigidity in Europe and Japan. This framework allows one to reconsider the policy conclusions derived from ad-hoc Mundell-Fleming models (Branson and Rotemberg, 1980; Argy and Salop, 1983; Bruno and Sachs, 1985; van der Ploeg, 1987b) in an internally consistent fashion. In particular, it allows one to consider the intertemporal aspects of the view that a European fiscal expansion is a locomotive policy whilst a US fiscal expansion is, typically, a beggar-thy-neighbour policy.

A European fiscal expansion, when tax rules are used to stabilise the government debt, leads on impact to a jump appreciation of the real exchange rate which overshoots its equilibrium value, a fall in real interest rates, a fall in European consumption of home goods, an increase in European imports, a fall in European exports, an increase in European and US output and employment, and a fall in US consumption. Hence, as far as output is concerned, a European fiscal expansion is a locomotive policy in the short run. Over time the European government debt builds up and the trade deficits lead to Europe becoming a debtor nation. To finance its debt service, Europe requires a trade surplus in the long run and therefore its real exchange rate depreciates over time. It follows that in the long run European consumption falls even more whilst US consumption increases. A US fiscal expansion leads on impact to undershooting of its real exchange rate, an increase in US output and employment, a fall in US consumption, and a fall in European output, employment and consumption. Hence, a US fiscal expansion is a beggar-thy-neighbour policy in the short run. Over time the US real exchange rate continues to appreciate, which further raises the European wedge between the consumers' and producers' wages and thus further depresses European output and employment. The US emerges as a debtor nation.

An autonomous reduction in US tax receipts leads to misadjustment of the terms of trade, consumption in both countries and European employment; on impact (in the long run) the US real exchange rate appreciates (depreciates), European consumption, output and employment fall (increase), and US consumption increases (falls). Hence, a cut in US taxes is a beggar-thy-neighbour policy in the short run but a locomotive policy in the long run. The political economy of the US under Mr. Reagan suggests that cuts in US taxation gradually lead to increases in US government debt and only then to cuts in government spending, hence a rule for government spending to ensure the solvency of the government's finances may be more realistic. Because people anticipate future cuts in government spending rather than increases in taxes, human wealth does not fall as much and consequently the impact effects on US output and employment are much larger. As the government cuts back, private consumption flourishes. When 'Reaganomics' is strong, that is when government spending reacts strongly to government debt, there is a much deeper (temporary) recession and as a result the

US debt is much less high and the US real exchange rate needs to depreciate much less.

The Sargent-Wallace (1981) arguments about unpleasant monetarist arithmetic can also be considered. When there is no tax rule or government spending rule to stabilise the government debt and when there is a limit to the amount of government bonds the private sector is prepared to purchase, an excess of government spending over taxes plus seignorage revenues must eventually be financed by either an increase in monetary growth or a structural fiscal adjustment. In the former case, tight money today implies high inflation tomorrow and, under perfect foresight, high inflation today. Also, in the process the government debt has increased and therefore one ends up with a permanently higher inflation rate in order to generate the seignorage revenues to meet the interest payments on the additional government debt (van Wijnbergen, 1985). In the latter case, one ends up with either a permanently lower level of government spending or a permanently higher level of taxation.

A US monetary disinflation leads on impact to an appreciation of the US real exchange rate, which misadjusts rather than overshoots its equilibrium value. As far as European consumption, output and employment is concerned, a US disinflation is a beggar-thy-neighbour policy in the short run and a locomotive policy in the long run. The reason is that over time the US becomes a debtor nation and requires a long-run depreciation of the US real exchange rate, which reduces the wedge between the European producers' and consumers' wage and consequently boosts European output and employment in the long run.

There are at least two important directions of future research. The first is concerned with the effects of capital accumulation in an interdependent world. The assumption of finite lives drives a wedge between the discount rate used to calculate government debt and the one used to calculate human wealth and thereby ensures that an increase in monetary growth reduces the world interest rate and increases both home and foreign capital accumulation (van der Ploeg, 1988). It is interesting to investigate such interdependent Mundell-Tobin effects in a two-country model with unemployment. The second direction is concerned with the international coordination of optimal

fiscal and monetary policies in a two-country world with micro foundations (Kehoe, 1987; van der Ploeg, 1987a). The recent work of Calvo and Obstfeld (1988) may be useful in this context.

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Figure 1: Effects of an increase in foreign government spending on the long-run equilibrium

Table 1: Parameters, exogeneous variables, initial conditions and eigenvalues

Parameter values

$$\alpha = 0.05, \quad \beta = 0.03,$$

$$\gamma_1 = 0.72, \quad \gamma_2 = 0.24, \quad \gamma_3 = 0.04, \quad \gamma_4 = \gamma_5 = 0.0, \quad \text{demand-side parameters}$$

$$\varphi_0 = 1, \quad \rho = 0.75, \quad \omega = 0, \quad \omega_0 = 0.77,$$

$$\psi^* = 0.05, \quad u_n^* = 0.1, \quad \text{supply-side parameters}$$

$$\xi_1 = 0 \text{ or } 0.5, \quad \xi_2 = 0, \quad \xi_3 = 0 \text{ or } 0.1, \quad \xi_4 = 0, \quad \text{reaction coefficients}$$

Exogeneous variables

$$Z_0 = Z_0^* = 0, \quad G_0 = G_0^* = 0.1, \quad \theta = \theta^* = 0.05$$

Initial conditions

$$D_0 = D_0^* = 0.18522618; \quad F_0 = 0, \quad X_0^* = 2.27554663$$

Eigenvalues ($\xi_1=0.5, \quad \xi_3=0.0$)

$$-0.016404; \quad -0.44837; \quad -0.40888; \quad -0.45169;$$

$$0.10261; \quad 0.10238; \quad 0.068067; \quad 0.000016887.$$

Table 2a: Fiscal expansion in Europe

Variable	Period	0	1	2	3	10	∞
<u>Europe</u>							
Y		2.64	2.63	2.61	2.60	2.55	2.19
C		-3.00	-3.02	-3.04	-3.06	-3.16	-4.00
C _d		-3.00	-3.02	-3.04	-3.06	-3.16	-4.00
C _m		0.43	0.39	0.38	0.32	0.15	-1.18
w		-0.87	-0.86	-0.86	-0.85	-0.84	-0.72
L		3.54	3.52	3.50	3.49	3.41	2.93
D		0	21.98	36.03	45.01	60.25	61.09
M		-3.25	-3.28	-3.31	-3.34	-3.44	-4.16
r		-0.02	-0.01	0.00	0.01	0.02	0.02
<u>US</u>							
Y*		0.09	0.06	0.04	0.02	-0.01	0
C*		-0.01	-0.04	-0.06	-0.07	-0.05	0.39
C _d *		-0.01	-0.04	-0.06	-0.07	-0.05	0.39
C _m *		-3.42	-3.43	-3.44	-3.43	-3.35	-2.46
w*		-0.03	-0.02	-0.01	-0.01	+0.00	0
L*		0.12	0.08	0.05	0.03	-0.01	0
D*		0	-0.02	-0.02	-0.02	0.03	-0.01
M*		-0.03	-0.06	-0.08	-0.10	-0.09	0.22
r*		-0.04	-0.02	-0.01	-0.01	0.01	0.02
<u>World</u>							
y		-3.42	-3.40	-3.38	-3.37	-3.30	-2.85
F		0	-0.09	-0.10	-0.27	-0.89	-6.11

Percentage deviations (except r, r* and F, for which it is 100 times the absolute deviation).

Table 2b: Fiscal expansion in the US

Period Variable	0	1	2	3	10	∞
<u>Europe</u>						
Y	-0.61	-1.29	-1.72	-2.00	-2.49	-2.17
C	-0.78	-1.54	-2.03	-2.34	-2.84	-2.05
C _d	-0.78	-1.54	-2.03	-2.34	-2.84	-2.05
C _m	-1.59	-3.25	-4.31	-4.99	-6.13	-4.93
w	0.2	0.43	0.58	0.67	0.83	0.73
L	-0.81	-1.71	-2.29	-2.67	-3.31	-2.89
D	0	-0.51	-0.58	-0.45	0.49	0.50
M	-0.82	-1.58	-2.07	-2.38	-2.90	-2.23
r	-0.95	-0.60	-0.39	-0.25	0.01	0.02
<u>US</u>						
Y*	4.29	2.80	1.84	1.22	0.08	0
C*	-1.17	-2.84	-3.91	-4.61	-5.94	-6.45
C _d *	-1.17	-2.84	-3.91	-4.61	-5.94	-6.45
C _m *	-0.36	-1.13	-1.63	-1.96	-2.65	-3.58
w*	-1.42	-0.93	-0.61	-0.41	-0.03	0
L*	5.72	3.74	2.46	1.63	0.11	0
D*	0	20.58	34.28	43.39	60.48	61.58
M*	-1.42	-3.11	-4.20	-4.91	-6.24	-6.63
r*	-2.08	-1.32	-0.85	-0.55	-0.01	0.02
<u>World</u>						
ν	0.81	1.72	2.30	2.68	3.34	2.91
F	0	0.10	0.18	0.27	0.90	6.11

Table 3: The short-run dependent of taxes in the EMS and the US, 1970-1980

Variable	Period	0	1	2	3	10	∞
<u>Europe</u>							
Y		-0.32	0.39	-0.43	-0.44	-0.27	2.48
C		-1.13	-1.20	-1.22	-1.20	-0.65	5.77
C _d		-1.13	-1.20	-1.22	-1.20	-0.65	5.77
C _m		-1.54	-1.71	-1.78	-1.78	-1.01	9.28
w		0.11	0.13	0.14	0.15	0.09	-0.81
L		-0.42	-0.52	-0.57	-0.59	-0.36	3.32
D		0	0.05	0.12	0.21	0.45	-0.66
M		-1.30	-1.38	-1.42	-1.41	-0.97	4.54
r		-0.11	-0.04	0.01	0.04	0.11	0.13
<u>US</u>							
Y*		0.76	0.58	0.44	0.34	0.09	0
C*		1.55	1.34	1.15	1.00	0.37	-3.09
C _d *		1.55	1.34	1.15	1.00	0.37	-3.09
C _m *		1.98	1.86	1.73	1.60	0.73	-6.20
w*		-0.25	-0.19	-0.15	-0.11	-0.03	0
L*		1.02	0.78	0.59	0.45	0.12	0
D*		0	173.80	284.90	356.04	478.14	483.88
M*		-0.25	-0.61	-0.88	-1.08	-1.72	-4.22
r*		-0.23	-0.11	-0.03	0.03	0.16	0.12
Z*		-46.06	-23.99	-13.61	-7.03	4.25	3.81
<u>world</u>							
y		0.42	0.52	0.57	0.59	0.36	-3.21
F		0	0.65	1.32	2.00	6.63	46.83

Percentage deviations (except r, r*, Z* and F, for which it is 100 = the absolute deviation).

Table 3b: Tax cut in US precedes cuts in government spending ($\xi_3 = 0.1$)

Period variable	0	1	2	3	10	∞
<u>Europe</u>						
Y	-0.80	-0.67	-0.26	0.31	5.61	29.72
C	-1.85	-1.70	-1.23	-0.58	5.49	38.30
C _d	-1.85	-1.70	-1.23	-0.58	5.49	38.30
C _m	-2.89	-2.58	-1.57	-0.17	13.45	95.65
w	0.27	0.22	0.09	-0.10	-1.80	-8.31
L	-1.06	-0.89	-0.35	0.41	7.55	41.47
D	0	0.18	0.67	1.32	6.28	4.32
M	-2.13	-2.01	-1.56	-0.93	4.97	35.56
r	-0.10	0.36	0.60	0.74	0.87	0.21
<u>US</u>						
Y*	1.82	-0.04	-1.22	-1.99	-2.91	0
C*	1.53	1.85	2.85	4.24	16.91	29.69
C _d *	1.53	1.85	2.85	4.24	16.91	29.69
C _m *	2.61	2.76	3.21	3.81	8.70	-8.33
w*	-0.60	0.02	0.41	0.67	0.99	0
L*	2.44	-0.06	-1.62	-2.64	-3.86	0
D*	0	11.34	23.02	34.79	112.12	259.86
M*	-0.60	-0.51	0.27	1.43	12.69	27.12
r*	-0.23	0.76	1.27	1.57	1.85	0.21
G*	0	-2.02	-4.10	-6.20	-19.97	-46.27
<u>world</u>						
ν	1.07	0.90	0.35	-0.41	-7.02	-29.32
F	0	1.15	2.37	3.67	14.49	204.48

Percentage deviations(except r, r*, G* and F for which it is 100 x the absolute deviation).

Table 3c: Tax cut US precedes cuts in government spending ($\xi_y = 0.5$)

Period	0	1	2	3	10	∞
<u>Europe</u>						
Y	-0.13	1.30	2.90	4.40	9.40	10.60
C	-0.41	1.15	2.85	4.40	9.28	11.53
C _d	-0.41	1.15	2.85	4.40	9.28	11.53
C _m	-0.58	2.91	6.84	10.56	23.18	27.56
w	0.04	-0.43	-0.95	-1.42	-2.95	-3.30
L	-0.17	1.74	3.88	5.91	12.73	14.38
D	0	1.25	1.99	2.19	-1.00	-2.50
M	-0.44	1.12	2.81	4.36	9.20	11.13
r	1.23	1.70	1.60	1.39	0.13	0.04
<u>US</u>						
Y*	0.30	-5.37	-7.54	-7.78	-0.68	0
C*	-0.55	4.06	7.98	11.67	23.75	22.67
C _d *	-0.55	4.06	7.98	11.67	23.75	22.67
C _m *	-0.72	9.81	9.79	9.75	9.43	7.25
w*	-0.10	1.86	2.65	2.74	0.23	0
L*	-0.39	-7.10	-9.92	-10.24	-0.91	0
D*	0	93.25	155.00	194.85	245.85	241.41
M*	-0.10	3.34	7.21	10.87	22.93	22.23
r*	2.69	0.18	0.10	0.06	0.05	0.04
G*	0	-8.44	-14.03	-17.64	-22.25	-21.85
<u>World</u>						
y	0.17	-1.71	-3.74	-5.58	-11.29	-12.57
F	0	0.27	0.55	0.84	2.84	18.89

Percentage deviations (except r, r* and F for which it is 100 x the absolute deviation).

Table 2a: Monetary disinflation in the US ($\Delta\theta^* = -0.5$)

Variable	0	1	2	10	15	∞
Europe						
Y	-1.58	-1.12	-0.79	-0.04	-0.01	0.05
ℓ	-1.77	-1.28	-0.90	-0.05	-0.01	0.12
C_m	-3.85	-2.75	-1.93	-0.10	-0.02	0.19
w	0.53	0.38	0.26	0.01	0.00	-0.02
L	-2.10	-1.49	-1.05	-0.05	-0.01	0.07
D	0	0.53	0.73	0.15	0.04	-0.01
M	-1.80	-1.29	-0.91	-0.06	-0.02	0.09
r	0.60	0.45	0.33	0.02	0.01	0.00
p	-0.60	-0.45	-0.33	-0.02	-0.00	0.00
US						
Y*	-3.38	-2.40	-1.68	-0.07	-0.01	0
ℓ^*	-3.77	-2.68	-1.86	-0.07	-0.01	-0.06
C_m^*	-1.71	-1.20	-0.83	-0.02	-0.00	-0.13
w*	1.15	0.81	0.57	0.02	0.00	0
L*	-4.49	-3.19	-2.23	-0.09	-0.01	0
D*	0	1.53	2.21	1.40	1.16	1.11
M*	1.15	2.31	3.17	5.06	5.13	5.09
r*	1.31	0.98	0.71	0.04	0.01	0.00
p*	-1.81	-1.47	-1.20	-0.53	-0.50	-0.50
θ^*	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
World						
y	2.15	1.52	1.06	0.05	0.01	-0.07
F	0	0.02	0.03	0.15	0.22	1.00

Percentage deviations (except r, r*, p, p*, θ^* and F for which it is 100 x the absolute deviation).

Table 4b: Unpleasant monetarist arithmetic in the US

Period	0	1	2	4	10	15	∞
Variable							
<u>Europe</u>							
Y	-0.05	0.10	0.21	0.37	0.77	0.20	0
C _d	-0.05	0.11	0.24	0.41	0.86	0.23	0
C _m	-0.11	0.25	0.52	0.91	1.90	0.49	0
w	0.02	-0.03	-0.07	-0.12	-0.26	-0.07	0
L	-0.06	0.13	0.28	0.49	1.03	0.27	0
D	0	0	0	0.0	0	0	0
M	-0.05	0.11	0.24	0.42	0.86	0.23	0
r	0.19	0.14	0.11	0.08	0.09	-0.06	0
p	-0.19	-0.14	-0.11	-0.08	-0.09	0.06	0
<u>US</u>							
Y*	-0.10	0.23	0.47	0.82	1.70	0.44	0
C _d *	-0.11	0.25	0.52	0.91	1.90	0.49	0
C _m *	-0.05	0.12	0.24	0.42	0.86	0.22	0
w*	0.03	-0.08	-0.16	-0.27	-0.56	-0.15	0
L*	-0.13	0.30	0.62	1.09	2.26	0.59	0
D*	0	1.24	2.48	5.09	15.93	16.05	16.11
M*	0.03	-0.12	-0.41	-1.34	-6.30	-8.69	-9.54
r*	0.42	0.31	0.24	0.17	0.19	-0.13	0
p*	-0.43	-0.27	-0.14	0.07	0.70	1.15	1.07
θ^*	-0.50	-0.50	-0.50	-0.50	-0.50	0.92	1.07
<u>World</u>							
v	0.06	-0.13	-0.28	-0.49	-1.02	-0.27	0
F	0.00	0.00	0.00	0.00	0.01	0.01	0

Percentage deviations (except r, r*, p*, θ^* and F for which it is 100 x the absolute deviation).

Table 5a: A real wage reduction in Europe

Variable	Period	0	1	10	∞
<u>Europe</u>					
Y		8.72	8.72	8.74	8.80
C		9.75	9.76	9.79	9.94
C _d		9.75	9.76	9.79	9.94
C _m		-0.08	-0.07	-0.02	0.19
w		-2.75	-2.75	-2.75	-2.77
L		11.79	11.79	11.81	11.90
D		0	-0.72	-1.99	-2.04
M		9.81	9.81	9.84	9.97
r		+0.00	+0.00	-0.00	-0.00
<u>US</u>					
Y*		-0.02	-0.01	+0.00	0.00
C*		+0.00	0.01	0.01	-0.06
C _d *		+0.00	0.01	0.01	-0.06
C _m *		9.84	9.84	9.82	9.66
w*		0.01	+0.00	0.00	0.00
L*		-0.02	-0.01	0.00	0.00
D*		0	0	-0.01	0.00
M*		0.01	0.01	0.02	-0.04
r*		0.01	+0.00	-0.00	-0.00
<u>World</u>					
ν		9.84	9.83	9.81	9.73
F		0	0.02	0.17	1.11

Percentage deviations (except r , r^* and F for which it is 100 x the absolute deviation).

Table 2b: A reduction in the natural rate of unemployment in the US

Variable	Period	0	1	2	3	10	∞
<u>Europe</u>							
Y		0	0.68	1.12	1.41	1.88	1.88
C		0.01	0.77	1.26	1.58	2.11	2.09
C _d		0.01	0.77	1.26	1.58	2.11	2.09
C _m		0.01	1.67	2.76	3.46	4.63	4.61
w		0	-0.23	-0.37	-0.47	-0.63	-0.63
L		0	0.90	1.49	1.87	2.51	2.51
D		0	0.55	0.70	0.58	-0.31	-0.44
M		0.02	0.78	1.27	1.59	2.13	2.12
r		0.93	0.61	0.40	0.25	0.01	0.00
<u>US</u>							
Y*		-0.01	1.48	2.45	3.07	4.12	4.31
C*		-0.02	1.65	2.74	3.44	4.62	4.69
C _d *		-0.02	1.65	2.74	3.44	4.62	4.69
C _m *		-0.02	0.75	1.24	1.56	2.10	2.17
w*		0.01	-0.49	-0.81	-1.02	-1.37	-1.38
L*		-0.01	1.97	3.27	4.10	5.50	5.56
D*		0	1.25	1.50	1.27	-0.67	-0.97
M*		0.01	1.67	2.76	3.46	4.64	4.71
r*		2.04	1.34	0.86	0.55	0.02	0.00
<u>World</u>							
ν		0	-0.90	-1.49	-1.87	-2.50	-2.50
F		0	-0.01	-0.01	-0.01	-0.04	-0.29

Percentage deviations (except r, r* and F for which it is 100 x the absolute deviation).

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