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INTERNATIONAL FISCAL POLICY TRANSMISSION

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Abstract

The paper examines international transmission of stochastic fiscal policy disturbances in a two-country general equilibrium framework, with possible excess supply equilibria with underutilization of resources. Nominal goods prices are sticky, although optimally set by firms in monopolistic competition. Asset prices are flexible. Agents have rational expectations. The spillover effect on foreign output of a domestic fiscal expansion differs from the standard positive Mundell-Fleming one, and depends on whether home and foreign goods are Edgeworth-Pareto complements or substitutes, which in turn depends on the relative size of intertemporal and intratemporal elasticities of substitution in consumption.

1. Introduction

This paper examines international transmission of fiscal policy. More precisely, in a two-country framework it looks at the effect of a home fiscal expansion on foreign output, the trade balance, exchange rates and interest rates.

The model combines elements from recent research on general equilibrium asset-pricing in international monetary economies (Lucas (1982), Kouri (1983), Svensson (1985), Stockman and Svensson (1985)) with a theory of sticky but optimally set nominal goods prices and demand determined output, developed in a closed economy framework by Svensson (1986a,b).

A standard tool for discussion of international transmission of policy is the classic Mundell-Fleming model.¹ It leads to very strong conclusions about international transmission of fiscal policy. Consider for instance the two-country version with flexible exchange rates and perfect capital mobility, the straight-forward flexible exchange rate extension of the fixed price IS-LM model with demand determined output. A fiscal expansion in the home country increases the demand for both home and foreign goods. The foreign trade balance improves. The home currency may depreciate or appreciate. In the new equilibrium the world rate of interest, which due to perfect capital mobility equals the home and foreign interest rates, has risen. For fixed money supplies, money market equilibrium requires that output must have risen in each country. In summary, fiscal policy is expansionary for both countries. (See Appendix for details.)

The IS-LM and hence the Mundell-Fleming model has obvious and well-known weaknesses. For instance, the behavioral functions, including the money demand functions, are not derived from intertemporal optimizing behaviour. Expectations are stationary. Considerable effort has been expended in the international macro

¹ Fleming (1962) and Mundell (1968). For a modern restatement, see Dornbusch (1980).

field remedying these inadequacies. Recent studies of international fiscal policy transmission in rigorous frameworks include Persson (1982), Greenwood and Kimbrough (1985) and Frenkel and Razin (1985). None of these papers integrate sticky but endogenous nominal goods prices and a demand determined output with a full stochastic rational expectations equilibrium.

To do that, and to use the model to study fiscal policy transmission, is the purpose of the present paper. By focussing on fiscal policy, the paper is a companion to Svensson and Wijnbergen (1986) which deals with monetary policy only, in the same framework. While deriving our results, we shall repeatedly contrast them with the Mundell-Fleming ones.

Section 2 presents the model and the equilibrium. Section 3 deals with fiscal policy effects on output. Section 4 discusses exchange rates, trade balance and interest rates. Section 5 presents some conclusions. An Appendix deals with some technical details, including a derivation of the price setting behaviour.

2. The Model

The model is identical to that of Svensson and Wijnbergen (1986), except that government expenditures are incorporated.² The world consists of two countries, home and foreign. Each country is completely specialized in the production of home and foreign goods, respectively. As further specified below and in the Appendix, there is production of differentiated products, but at this stage it is sufficient to consider two aggregate goods only. In period t ($t = -1, 0, 1, \dots$) world per capita production of each good, Y_t and Y_t^* , respectively, is costless up to an exogenous stochastic capacity level, y_t and y_t^* . Hence

$$(2.1) \quad Y_t \leq y_t \text{ and } Y_t^* \leq y_t^*.$$

There is a representative consumer in each country. Hence world population is 2,

² The presentation of the model is selfcontained, although various aspects of it are more fully discussed in Svensson and Wijnbergen (1986).

and world production of the two goods is $2Y_t$ and $2Y_t^*$, respectively. Goods are perishable. When output falls short of capacity, there is waste and underutilization of resources.

There are two governments, home and foreign, and two currencies, home and foreign. Each government finances government consumption of the country's own good by levelling lump-sum taxes on its representative consumer, and by issuing the country's currency. The (world per capita) supply of currencies in period t , $\bar{M}_t$ and $\bar{N}_t^*$, respectively, is stochastic and given by

$$(2.2) \quad \bar{M}_t = \omega_t \bar{M}_{t-1} \text{ and } \bar{N}_t^* = \omega_t^* \bar{N}_{t-1}^*,$$

where ω_t and ω_t^* are the (gross rates of) monetary expansion(s) of home and foreign currency. The budget constraint for the two governments are then

$$(2.3a) \quad P_{ht} g_t = T_t + (\omega_t - 1) \bar{M}_{t-1} \text{ and}$$

$$(2.3b) \quad P_{ft}^* g_t^* = T_t^* + (\omega_t^* - 1) \bar{N}_{t-1}^*,$$

where g_t is the (world per capita) home government's consumption of home goods, P_{ht} is the home currency price of home goods, and T_t is the (net, world per capita) taxes in home currency levelled on home consumers (T_t may be negative). Similarly, g_t^* is the foreign government's (world per capita) consumption of foreign goods, and P_{ft}^* and T_t^* are foreign currency prices of foreign goods and taxes on foreign consumers, respectively.

We call the vector $s_t = (y_t, y_t^*, g_t, g_t^*, \omega_t, \omega_t^*)$ the state. We assume that the states are serially independently distributed, and that their probability distribution is given by the time-invariant probability distribution function $F(s_t)$. Thus we shall consider capacity, government consumption, and monetary expansion in the two countries as exogenous. This implies that in equilibrium taxes in (2.3) are endogenously determined, together with the other endogenous variables.

Since there are lumpsum taxes and infinitely lived consumers, our model has Ricardian equivalence. That is, shifts between taxes and issue of government bonds are completely neutral. Therefore we might as well assume, as in (2.3), that no borrowing takes place, and that the only means to finance government expenditure is either to tax or to print money.

The home and the foreign consumer have identical preferences. Let us consider the situation for the home consumer. His preferences in period t are given by the expected utility function

$$(2.4) \quad E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} u(c_{h\tau}, c_{f\tau}), \quad 0 < \beta < 1.$$

Here E_t denotes the expectations operator conditional upon information available in period t ; $u(c_{ht}, c_{ft})$ is a standard concave instantaneous utility function of (private) consumption c_{ht} and c_{ft} of home and foreign goods, respectively, in period t . We assume that government consumption enters either additively separable in the utility function, or not at all. In both cases we can disregard the effect of government consumption on consumers' preferences for private consumption.

We need to specify the timing of markets and transactions facing the consumer. We shall explain it in some detail for the home consumer. The home consumer enters period t with stocks of four different assets, namely home and foreign currency, M_{t-1} and N_{t-1} , and shares in home and foreign firms, z_{ht-1} and z_{ft-1} . In addition he has two liabilities, namely to pay taxes to the home and foreign government. These latter liabilities, denoted x_{ht-1} and x_{ft-1} , may require some explanation. Although each government levies taxes only on its own consumer, the risk-averse consumers have an incentive to diversify the risk of tax payments. Hence, in the absence of any legal restrictions, trade in liabilities to pay taxes will result. Hence, in equilibrium, each government will in effect tax consumers from both countries.

In the beginning of the period the consumer learns the current state s_t of current capacities, governments' consumptions and monetary expansions, and he pays the taxes in home and foreign currency, in proportion to his liabilities. After that, the goods market opens. On the goods market the consumer can buy home and foreign goods. He must pay for home goods with home currency and for foreign goods with foreign currency.³ Hence he faces the liquidity constraints

$$(2.5a) \quad P_{ht} c_{ht} \leq M_{t-1} - T_{ht-1} \text{ and}$$

$$(2.5b) \quad P_{ft}^* c_{ft} \leq N_{t-1} - T_{ft-1}^*.$$

Since nominal goods prices will be sticky and not adjust to the current state of the market, there will be excess demand in some states and excess supply in others. When there is excess demand consumers will be rationed. We assume that governments are never rationed. Then the home consumer also faces the rationing constraints

$$(2.6a) \quad c_{ht} \leq Y_t - g_t \text{ and}$$

$$(2.6b) \quad c_{ft} \leq Y_t^* - g_t^*$$

(recall that Y_t is output per capita).⁴

After the consumer's transactions on the goods market, that market closes and the asset market opens. On the asset market, dividends on shares in firms (cash from sales of output) are distributed, and the consumer can trade assets and liabilities according to the budget constraint

$$(2.7) \quad M_t + e_t N_t + Q_{ht} z_{ht} + Q_{ft} z_{ft} + R_{Mt} x_{Mt} + R_{Nt} x_{Nt} \leq \\ \leq [M_{t-1} - T_{ht-1} - P_{ht} c_{ht}] + e_t [N_{t-1} - T_{ft-1}^* - P_{ft}^* c_{ft}] +$$

³ In the terminology of Helpman and Razin (1984), this is the S-system, where the sellers nationality determines the transactions currency. They also consider the B-system, where the nationality of the buyer determines the transactions currency.

⁴ We exploit that in equilibrium either none or both consumers will be rationed, and we assume that in the latter case they receive identical rations.

$$+ (Q_{ht} + P_{ht} Y_t) z_{ht-1} + (Q_{ft} + e_t P_{ft}^* Y_t^*) z_{ft-1} + R_{ht} x_{Mt-1} + R_{ft} x_{Nt-1}.$$

Here e_t is the exchange rate, Q_{ht} and Q_{ft} are the home currency prices of shares in home and foreign firms, respectively, and R_{ht} and R_{ft} are the home currency prices of the liabilities to pay home and foreign taxes, respectively (R_{ht} and R_{ft} will both be negative if taxes are expected to be positive). The inequality (2.7) simply states that the value of end-of-period assets and liabilities plus the value of current period consumption cannot exceed the value of assets and liabilities carried over from the previous period plus current period income. After these transactions the asset market closes, and the home consumer leaves period t and enters period $t+1$ with new stocks of his six assets and liabilities, M_t , N_t , z_{ht} , z_{ft} , x_{ht} and x_{ft} .

The home consumer will maximize expected utility (2.4) subject to the sequence of liquidity, rationing and budget constraints (2.5) - (2.7). The foreign consumer will maximize the same utility function, with the same constraints, only his variables are denoted by '*', like c_{ht}^* , c_{ft}^* , M_t^* , N_t^* . etc.

Before characterizing the equilibrium, let us briefly discuss price setting behaviour. As is further specified in the Appendix, home (foreign) firms produce differentiated home (foreign) goods in monopolistic competition. Firms set prices in their own currency.⁵ For some reason they must set prices one period in advance, that is before the current state is known, for instance because it takes time to implement a price change, or because they cannot observe the current state of the economy except with a lag. Hence, own-currency goods prices P_{ht+1} and P_{ft+1}^* will be predetermined and prices in period $t+1$ can only depend on the state variables in period t . These will turn out to be the state s_t , the money stocks $\bar{M}_{t-1}$ and $\bar{N}_{t-1}^*$, and the predetermined price levels P_{ht} and P_{ft}^* . Introducing the

⁵ See Giovannini (1985) for an analysis of what determines whether firms prefer to set prices in home or foreign currency.

notation $\pi_M = 1/P_h$ and $\pi_N^* = 1/P_f^*$ for the own-goods prices of home and foreign currency, we can write the pricing function (assumed stationary) as

$$(2.8a) \quad \pi_{Mt+1} = \Pi_M(s_t, \bar{M}_{t-1}, \bar{N}_{t-1}^*, \pi_{Mt}, \pi_{Nt}^*) \text{ and}$$

$$(2.8b) \quad \pi_{Nt+1}^* = \Pi_N^*(s_t, \bar{M}_{t-1}, \bar{N}_{t-1}^*, \pi_{Mt}, \pi_{Nt}^*).$$

These functions are the result of the home and foreign firms maximizing their stock market values, as discussed in further detail in the Appendix. However, since the states are serially uncorrelated, the current state conveys no information about the state of tomorrow's markets. Hence, the pricing will be to some extent independent of the current state. Also, there is no money illusion in this world. Then prices for period $t+1$ are set proportionally to the stocks of money in period t . It follows that the pricing functions have the simple form

$$(2.9a) \quad \pi_{Mt+1} = k/\bar{M}_t = k/\omega_t \bar{M}_{t-1} \text{ and}$$

$$(2.9b) \quad \pi_{Nt+1}^* = k^*/\bar{N}_t^* = k^*/\omega_t^* \bar{N}_{t-1}^*,$$

where the constants k and k^* depend on the parameters of the model, including the probability distribution $F(s_t)$, and are determined as in the Appendix.⁶

We consider a perfectly pooled equilibrium, where the home and foreign consumer hold identical portfolios and consume identical quantities of the goods. That is, they hold the same per capita share of world assets and liabilities and consume the same per capita share of world output, net of government consumption of each good. Then the market equilibrium condition for the goods, money and other asset markets can be written

$$(2.10a) \quad c_{ht} = c_{ht}^* = Y_t - g_t \leq y_t - g_t,$$

$$(2.10b) \quad c_{ft} = c_{ft}^* = Y_t^* - g_t^* \leq y_t^* - g_t^*.$$

⁶ Note that the prices in period $t+1$, although they are independent of y_t and y_t^* , actually depend on part of the states in t , namely monetary expansion ω_t and ω_t^* , in addition to the money stocks $\bar{M}_{t-1}$ and $\bar{N}_{t-1}^*$.

$$(2.10b) \quad M_t = M_t^* = \bar{M}_t \text{ and } N_t = N_t^* = \bar{N}_t^*, \text{ and}$$

$$(2.10c) \quad z_{ht} = z_{ft} = z_{ht}^* = z_{ft}^* = x_{ht} = x_{ft} = x_{ht}^* = x_{ft}^* = 1.$$

Note that total output is $2Y_t$ and $2Y_t^*$, total money stocks $2\bar{M}_t$ and $2\bar{N}_t^*$, total government consumption is $2g_t$ and $2g_t^*$, and that total quantity of each other asset and liability is normalized to equal 2. The inequalities in the goods market equilibrium conditions (2.10a,b) allow for the possibility of excess supply and underutilization of resources.

The first-order conditions for the consumers and their liquidity, rationing and budget constraints, together with the market equilibrium conditions (2.10), determine the equilibrium. The equilibrium equations can be written (see Appendix for details)

$$(2.11a) \quad c_h \leq kw - g \quad [\mu_h \geq 0],$$

$$(2.11b) \quad c_h \leq y - g \quad [v_h \geq 0],$$

$$(2.11c) \quad u_h(c_h, c_f) = \lambda + \mu_h + v_f,$$

$$(2.11d) \quad \lambda = A/\omega \text{ where } A = \beta E[\lambda' + \mu_h'],$$

$$(2.12a) \quad c_f \leq k^*\omega^* - g^* \quad [\mu_f^* \geq 0],$$

$$(2.12b) \quad c_f \leq y^* - g^* \quad [v_f^* \geq 0],$$

$$(2.12c) \quad u_f(c_h, c_f) = \lambda^* + \mu_f^* + v_f^*, \text{ and}$$

$$(2.12d) \quad \lambda^* = A^*/\omega^* \text{ where } A^* = \beta E[\lambda^{*'} + \mu_f^{*'}].$$

The notation and equations need some explanation. A variable with a prime (') denotes a variable in period $t+1$, one without a prime refers to period t . Equation (2.11a) is the liquidity constraint for home goods, specifying that home goods output cannot exceed real balances in home currency (note that by (2.2) and (2.9) real balances $\pi_M \bar{M} = (k/\bar{M}_{-1})\bar{M} = kw$). The variable μ_h is the Lagrange multiplier of the home currency liquidity constraint and v_h the multiplier of the home capacity constraint (2.11b). The brackets denote the usual complementary slackness

conditions.

Equation (2.11c) indicates that the marginal utility of home goods consumption equals the marginal utility of wealth measured in terms of home goods (λ), plus the sum of the multipliers associated with the home liquidity and capacity constraint. Clearly, a binding liquidity or capacity constraint drives a wedge between the marginal utility of consumption and the marginal utility of wealth: if spending plans cannot be executed, the latter falls short of the former.

A particular property of the equilibrium is that the marginal utility of wealth measured in home goods, λ in (2.11d), depends only on home monetary expansion, and more precisely is inversely proportional to home monetary expansion. This can be understood as follows. One unit of wealth measured in home goods in period t , the marginal utility of which is λ , corresponds to $1/\pi_\mu = P_h$ units of home currency. Carrying that amount of home currency into the next period gives present marginal utility equal to $\beta E[(\lambda' + \mu_h')\pi_M']/\pi_M$, which can be written A/ω with $A = \beta E[\lambda' + \mu_h']$ constant because of serially uncorrelated shocks, and $\pi_M'/\pi_M = 1/\omega$ by the pricing function (2.9a). In equilibrium these two marginal utilities must be equal. Put differently, the present marginal utility of next period's real balances, A , is constant. Current monetary expansion determines the rate of inflation ($P_h'/P_h = 1/\omega$) and hence the rate of transformation between current real wealth and next period real balances. This ties down the current marginal utility of real wealth.

A similar set of constraints holds for consumption of foreign goods (2.12a-d). Here λ^* is the marginal utility of wealth measured in foreign goods, μ_f^* is the marginal utility of foreign currency real balances, measured in foreign goods, and ν_f^* is the multiplier of the foreign goods rationing constraint. The

marginal utility of wealth measured in foreign goods is inversely proportional to the foreign monetary expansion, by an analogous argument as above.

It is indeed quite convenient that the variables and equations can be decomposed into the two groups of (2.11) and (2.12). For we note that from (2.11) we can solve for the endogenous variables c_h , λ , μ_h and v_h as functions of the exogenous variables y , g and ω , and consumption of foreign goods c_f . From (2.12) we can solve for c_f , λ^* , μ_f^* and v_f^* as functions of y^* , g^* , ω^* , and c_h . Thus we can write

$$(2.13a) \quad c_h = \tilde{C}_h(y, g, \omega, c_f) \text{ and}$$

$$(2.13b) \quad c_f = \tilde{C}_f(y^*, g^*, \omega^*, c_h),$$

which we call the partial consumption functions, for convenience. For given foreign consumption, home consumption depends only on home capacity and home monetary expansion and not on foreign capacity and foreign monetary expansion. Vice versa for foreign consumption.

From (2.13) we can then solve for home and foreign consumption as the functions (assuming any solution is unique)

$$(2.14a) \quad c_h = C_h(y, y^*, g, g^*, \omega, \omega^*) \text{ and}$$

$$(2.14b) \quad c_f = C_f(y, y^*, g, g^*, \omega, \omega^*),$$

where home and foreign consumption both depend on the state $s = (y, y^*, g, g^*, \omega, \omega^*)$. We call these functions the equilibrium consumption functions. Then the output functions are given by

$$(2.15a) \quad Y = Y(y, y^*, g, g^*, \omega, \omega^*) = C_h(y, y^*, g, g^*, \omega, \omega^*) + g, \text{ and}$$

$$(2.15b) \quad Y^* = Y^*(y, y^*, g, g^*, \omega, \omega^*) = C_f(y, y^*, g, g^*, \omega, \omega^*) + g^*.$$

3. International Output Effects of Fiscal Policy

We want to look closer at the effect of home government consumption on foreign output, that is the derivative Y_g^* (when this derivative exists, which will

be in the interiors of the regions to be specified below). Since we will be interested in a money-financed fiscal expansion, as well as a tax-financed one,⁷ we will also need the effect of a home monetary expansion on foreign output, that is the derivative Y_{ω}^* . It is clear from (2.13-15) that these derivatives are given by

$$(3.1a) \quad Y_g^* = C_{fg} = \tilde{C}_{fh} C_{hg} \text{ and}$$

$$(3.1b) \quad Y_{\omega}^* = C_{f\omega} = \tilde{C}_{fh} C_{h\omega}, \text{ where}$$

$$(3.2a) \quad C_{hg} = \tilde{C}_{hg}/\Lambda \text{ and } C_{h\omega} = \tilde{C}_{h\omega}/\Lambda, \text{ with}$$

$$(3.2b) \quad \Lambda = 1 - \tilde{C}_{hf}\tilde{C}_{fh}.$$

Equation (3.1a) shows, that the effect of a home fiscal expansion on foreign output is transmitted solely through the total effect of a home fiscal expansion on consumption of home goods, C_{hg} , and the effect on consumption of foreign goods of consumption of home goods, $\tilde{C}_{fh}$. The former effect is by (3.2a) the effect on consumption of home goods at constant consumption of foreign goods, $\tilde{C}_{hg}$, times the multiplier $1/\Lambda$, given by (3.2b) in a standard way. Hence we need to know the derivatives $\tilde{C}_{fh}$, $\tilde{C}_{hf}$, $\tilde{C}_{hg}$ and $\tilde{C}_{h\omega}$.

We shall thus look more closely at the function (2.13a) for home consumption. It can be illustrated as in Figure 1. The figure is drawn under the assumption that

$$(3.3) \quad \left| \frac{\epsilon_{u_h}(c_h, c_f)}{\epsilon_{c_h}} \right| < 1,$$

where ϵ_y/ϵ_x denotes the partial elasticity $(x/y)\partial y/\partial x$. That is, the elasticity of marginal utility of consumption of home goods with respect to home goods is less than unity.

The figure shows home consumption as a function of home capacity and monetary

⁷ Recall that due to Ricardian equivalence, tax-financing is equivalent to bond-financing. Hence the two cases to distinguish are tax-financed and money-financed increases in government consumption.

expansion, for a given level of foreign consumption, and for a given level of home government consumption. There are three regions in (y, ω) -space, corresponding to different regimes in the market. We first define the critical levels of home capacity and monetary expansion, $\bar{y}(g, c_f)$ and $\bar{\omega}(g, c_f)$, for which both the liquidity and rationing constraints (2.11a) and (2.11b) are just binding, and for which the corresponding Lagrange multipliers are zero. This gives

$$(3.4a) \quad \bar{\omega} = A/u_h(\bar{y}-g, c_f) \text{ and } \bar{\omega} = \bar{y}/k,$$

which implicitly determines $(\bar{y}(g, c_f), \bar{\omega}(g, c_f))$.

Then region U, the underconsumption regime, is defined by the set of points (y, ω) fulfilling $\omega \leq \min(A/u_h(y-g, c_f), \bar{\omega}(g, c_f))$. In region U,

$$(3.4b) \quad c_h = \varphi_h(\lambda, c_f) = \varphi_h(A/\omega, c_f) \leq \min(k\omega, y) - g, \text{ and } \mu_h = v_h = 0.$$

The function $\varphi_h(\lambda, c_f)$ is the inverse of the marginal utility of home consumption with respect to home consumption. That is, it is defined by

$$(3.4c) \quad u_h(\varphi_h(\lambda, c_f), c_f) = \lambda.$$

Region L, the liquidity shortage regime, is given by the set of points (y, ω) fulfilling $y \geq \bar{y}(g, c_f)$ and $\bar{\omega}(g, c_f) \leq \omega \leq y/k$. There

$$(3.4d) \quad c_h = k\omega - g \leq y - g, \mu_h \geq 0 \text{ and } v_h = 0.$$

Finally, region F, the full capacity regime, is given by the set of points (y, ω) fulfilling $\omega \geq \max(A/u_h(y-g, c_f), y/k)$. There

$$(3.4e) \quad c_h = y - g \leq k\omega - g, v_h \geq 0 \text{ and } \mu_h = 0.$$

Equations (3.4a-e) define the home goods consumption function (2.13a) for the three regions U, L and F. Let us look at the function in the different regions. In region U there is excess supply and neither the liquidity constraint nor the rationing constraint binds. There is excess supply of home goods. Consider a point (y, ω) in region U. Why is consumption of home goods so low? One way to understand this is to note that home monetary expansion is relatively low in this region.

Next period's price level is proportional to the current money stock and current monetary expansion. The current price level is predetermined and proportional to last period's money stock. Hence the (gross) inflation rate fulfills

$$(3.5) \quad P'_h/P_h = \frac{\omega \bar{M}_{-1}/k}{\bar{M}_{-1}/k} = \omega$$

and is relatively low. This means that the total return to holding home currency is relatively high, which implies that consumers prefer to hold larger home real balances and consume relatively little home goods. Suppose now that the rate of home monetary expansion increases, that is, the point (y, ω) in region U moves north. This increases the rate of home inflation and decreases the return to holding home currency, which in turn makes the consumer want to decrease home real balances and increase consumption of home goods. If home capacity is low, that is, below the critical level $\bar{y}(g, c_f)$, eventually the capacity constraint will bind, and the point enters region F where there is excess demand and full capacity. There the capacity constraint binds but not the liquidity constraint. If home capacity is high, that is, above the critical level $\bar{y}(g, c_f)$, the liquidity constraint eventually binds, and the point enters region L, where output of home goods equals home real balances. If home monetary expansion increases further, home real balances and consumption of home goods increase, eventually the capacity constraint binds and the point (y, ω) enters region F. Hence we understand what determines the derivative $\tilde{C}_{h\omega}$.

Let us also see how consumption of home goods is affected by an increase in foreign consumption, for given levels of home capacity and monetary expansion, that is, the derivative $\tilde{C}_{hf}$. By symmetry, we can then infer the properties of the derivative $\tilde{C}_{fh}$. We have already seen from (3.1) that the effect on home consumption of foreign consumption comes solely through the effect of foreign

consumption on the marginal utility of home consumption in (2.11c) and (3.4b,c). Suppose the cross-derivative $u_{hf}(c_h, c_f)$ is positive, that is, home and foreign goods are Edgeworth-Pareto complements. Then an increase in foreign consumption will increase the marginal utility of home consumption, which will increase home consumption in region U, whereas home consumption will not change in regions L and F. This is so, since home consumption depends on the marginal utility of home consumption only in region U, not in region L and F, where consumption is either liquidity or supply constrained.

Finally, we consider the effect on consumption of home goods of home government consumption, that is the derivative $\tilde{C}_{hg}$. It is clear from (3.4) that in region L and F government consumption crowds out consumption of home goods one to one, whereas in region U it does not crowd out consumption of home goods at all.

We summarize our findings about the relevant derivatives:

$$\begin{aligned}
 (3.6a) \quad \tilde{C}_{hg} &= \begin{matrix} 0 & (U), \\ 0 & (L), \\ -1 & (F) \text{ and} \end{matrix} \\
 (3.6b) \quad \tilde{C}_{hw} &= \begin{matrix} \varphi_{h\lambda} \lambda_w = -\lambda / (u_{hh} w) > 0 & (U), \\ k & (L), \\ 0 & (F) \text{ and} \end{matrix} \\
 (3.6c) \quad \tilde{C}_{hf} &= \begin{matrix} -u_{hf} / u_{hh} & (U), \\ 0 & (L) \text{ and} \\ 0 & (F). \end{matrix}
 \end{aligned}$$

Here, (U), (L) and (F) denote the corresponding regime of the home goods market.

By symmetry, we directly get the foreign goods consumption function (2.13b), under the assumption

$$(3.7a) \quad \left| \frac{\epsilon u_f(c_h, c_f)}{\epsilon c_f} \right| < 1.$$

The critical levels of foreign capacity and monetary expansion, $\bar{y}^*(g^*, c_h)$ and $\bar{\omega}^*(g^*, c_h)$, are given by

$$(3.7b) \quad \bar{\omega}^* = A^*/u_f(c_h, \bar{y}^* - g^*) \text{ and } \bar{\omega}^* = \bar{y}^*/k.$$

The regions U^* , L^* and F^* for foreign goods consumption are defined in complete analogy with the regions U , L and F for home goods consumption, and we have the derivative

$$(3.8) \quad \tilde{C}_{fh} = \begin{matrix} -u_{fh}/u_{ff} & (U^*), \\ 0 & (L^*) \text{ and} \\ 0 & (F^*). \end{matrix}$$

Combining (3.6c) and (3.8) we see that the multiplier fulfills

$$(3.9) \quad \Lambda = \begin{matrix} 1 - u_{hf}^2/u_{hh}u_{ff} > 1 & (U; U^*) \text{ and} \\ 1 & (\text{all other regions}), \end{matrix}$$

where we exploit concavity of the utility function. Here (a;b) denotes regime $a = U, L$ or F for the home goods market and regime $b = U^*, L^*, F^*$ for the foreign goods market. Only when the home goods and foreign goods markets are in regime U and U^* , respectively, is the multiplier larger than unity. In all other combinations of regimes it is unity, since one or both cross-effects are zero.

Let us summarize our findings. A fiscal expansion in the home country leads to an increase in output of home goods, if the home goods market is characterized by under-consumption. There is no effect on home output if there is full capacity or a liquidity shortage in the home goods market. What matters for the international transmission is the effect on consumption of home goods, though. Consumption of home goods is unaffected when there is underconsumption of home goods, but it falls when there is full capacity or liquidity shortage. Consumption of foreign goods is affected by consumption of home goods only if there is under-consumption of foreign goods. The sign of the effect depends on whether home and foreign goods are Edgeworth-Pareto complements or substitutes in production. The effect on output of foreign goods, finally, is given by the effect on demand and consumption of foreign goods, since output is demand determined when there is

excess capacity.

We can express this as

$$(3.10) \quad \begin{array}{ccccc} & Y_g^* & U^* & L^* & F^* \\ & U & 0 & 0 & 0 \\ & L & \bar{+} & 0 & 0 \\ & F & \bar{+} & 0 & 0 \end{array}$$

where rows and columns correspond to regions in the home and foreign goods markets, respectively, and the notation $\bar{+}$ refers to whether home and foreign goods are Edgeworth-Pareto complements or substitutes ($u_{hf} = \bar{+}$, note that when u_{hf} is positive (negative) and the goods are Edgeworth-Pareto complements (substitutes), the derivative Y_g^* in regions (L and F; U^*) is negative (positive)).

The experiment undertaken above is a tax-financed increase in home government consumption, since when monetary expansion is held constant, by (2.3a) taxes are increased (recall that due to Ricardian equivalence tax-financing is equivalent in its effects to bond-financing). Let us instead undertake an experiment when the increase in government consumption is financed via issue of home currency. From the budget constraint (2.3a) we see that such a fiscal expansion fulfills

$$(3.11) \quad dg = \pi_M \bar{M}_{-1} d\omega,$$

which by (2.9a) implies

$$(3.12) \quad d\omega = dg/k.$$

Hence the effect on foreign output is given by

$$(3.13) \quad dY^* = (Y_g^* + Y_\omega^*/k)dg.$$

We simply need to add the effects of the monetary expansion to the effects we have derived in (3.10). From (3.1b) and (3.2b) we know that we need the derivative $\tilde{C}_{h\omega}$, which we have already discussed and derived in (3.6b). Since a home monetary expansion increases home consumption when there is underconsumption and liquidity shortage but not when there is full capacity, we directly get the effect on

foreign output,

	Y_{ω}^*	U^*	L^*	F^*
(3.14)	U	$\pm$	0	0
	L	$\pm$	0	0
	F	0	0	0 .

Combining (3.10) and (3.14) and using (3.6) we finally get

	$Y_g^* + Y_{\omega}^*/k$	U	L^*	F^*
(3.15)	U	$\pm$	0	0
	L	0	0	0
	F	$\mp$	0	0 .

Take the case when home and foreign goods are Edgeworth-Pareto complements (the cross-derivative u_{hf} is positive). When there is underconsumption of home goods, the home monetary expansion increases consumption of home goods, whereas the fiscal expansion has no effect. The net effect on consumption of foreign goods and foreign output is positive when there is underconsumption of foreign goods. When there is a liquidity shortage in the home goods market, the effect on the fiscal expansion and the monetary expansion on home goods consumption cancel - the home government simply prints money to purchase home goods which increases output of home goods but leaves the liquidity constrained consumers unaffected. The net effect on consumption of foreign goods and foreign output is zero. Finally, when there is full capacity in home goods production, the home monetary expansion has no effect on consumption or output of home goods, whereas the fiscal expansion leaves output unchanged but crowds out consumption of home goods one to one. The net effect on consumption and output of foreign goods is negative, when there is underconsumption of foreign goods.

There is a sharp contrast to the Mundell-Fleming results. There, as we recall, a home fiscal expansion always increases foreign output. An increase in home government consumption in the Mundell-Fleming world had better be interpreted

as a bond-financed expansion. In our model, due to the Barro-Ricardo equivalence, ~~this is equivalent to a tax-financed expansion, that is, to our experiment~~ involving a change in g only, with ω held constant. This is what we have derived in (3.10). In the situation which is most similar to the Mundell-Fleming one, namely underconsumption in both home and foreign goods, we see that the effect is indeed zero.

We conclude that we have not at all been able to support the Mundell-Fleming result in our more rigorous model.

The discussion above has emphasized the importance of the sign of the cross derivative u_{hf} of the utility function, since determines the sign of the derivative $\tilde{C}_{fh}$, the effect of consumption of home goods on foreign goods consumption. As is shown in Svensson and Wijnbergen (1986), the sign of the cross derivative and hence whether goods are Edgeworth-Pareto complements or substitutes depends on the relative size of the intertemporal elasticity of substitution in consumption and the intertemporal substitution. Let us consider the CES utility function

$$(3.16a) \quad u(c_h, c_f) = U(c_h, c_f)^{1-1/\sigma} / (1 - 1/\sigma), \quad \sigma > 0, \quad \sigma \neq 1, \text{ and}$$

$$u(c_h, c_f) = \log U(c_h, c_f), \quad \sigma = 1, \text{ where}$$

$$(3.16b) \quad U(c_h, c_f) = [\gamma c_h^{1-1/s} + (1-\gamma) c_f^{1-1/s}]^{1/(1-1/s)}, \quad s > 0, \quad s \neq 1, \text{ and}$$

$$U(c_h, c_f) = c_h^\gamma c_f^{1-\gamma}, \quad s = 1.$$

That is, the intertemporal elasticity of substitution in consumption is the constant σ , and the intratemporal elasticity of substitution in consumption between home and foreign goods is the constant s .

With this utility function, it can be shown (see Appendix) that

$$(3.17) \quad \text{sign } u_{hf} = \text{sign } (\sigma - s).$$

This result follows since it can be shown that the elasticity of the partial

home goods consumption function (2.13a) with respect to foreign consumption can be decomposed into two terms of opposite signs, the positive term having to do with intertemporal substitution, and the negative term having to do with intratemporal substitution. See Svensson and Wijnbergen (1986) for further discussion and a diagrammatic illustration of that result.

In fact it can be shown (see Appendix) that assumptions (3.3) and (3.7a) together imply that the intertemporal elasticity of substitution exceeds the intratemporal one, and hence that the cross derivative should be positive. However, assumptions (3.3) and (3.7a) are only made in order to determine the relative locations of the regions in Figure 1. They are not necessary for the solution of the consumption functions within each region. Hence it is possible to have equilibria also with the intertemporal elasticity of substitution falling short of the intratemporal one, and hence with the cross derivative being negative. However, then the regions in state space describing the various situations in the market are located differently than in Figure 1.⁸

4. Exchange Rates, Terms of Trade, The Trade Balance, and Interest Rates

From (2.12) and (2.13) all endogenous variables, not only the partial consumption functions (2.13), can be solved for. The terms of trade will by the Appendix and (2.11d) and (2.12d) be given by

$$(4.1) \quad p = \frac{eP_f^*}{P_h} = \frac{\lambda^*}{\lambda} = \frac{A^*\omega}{A\omega^*},$$

which defines the terms of trade function $p(\omega, \omega^*)$. The exchange rate⁹ is given by

⁸ If (3.3) does not hold, region U in Figure 1 will be northeast, region L will be southeast, and region F remains northwest. The form of the borderlines also change. See Svensson (1986b) for details in the closed-economy case.

⁹ Note that this exchange rate is the one that rules on the asset market after the goods market is closed. The terms of trade (4.1) are here defined from that exchange rate although goods are actually not traded directly against each other at relative prices equal to those terms of trade. (They are traded against

$$(4.2) \quad e = \frac{p\pi_N^*}{\pi_M} = \frac{A^*k}{Ak^*} \frac{\omega_M}{\omega_N^*}.$$

We see that neither the exchange rate nor the terms of trade are affected by government consumption.

Let us recall the Mundell-Fleming results on the foreign trade balance response to a home fiscal expansion. Since the foreign trade balance is what actually transmits the disturbance, and since the foreign trade balance varies monotonically with foreign output for given foreign money supply (see Appendix for details), we can directly conclude that the foreign trade balance improves from a home fiscal expansion.

Let us now look at the trade balance response in our model. The foreign trade balance is given by

$$(4.3) \quad X^* = c_f - c_h^*/p.$$

Since foreign consumption of home goods equals home consumption of home goods

($c_h^* = c_f$) we can write the trade balance as

$$(4.4) \quad X^* = c_f - c_h/p.$$

Substituting (2.14) for c_f and c_h and the terms of trade function $p(\omega, \omega^*)$ for p , we get the foreign trade balance function $X^*(y, y^*, g, g^*, \omega, \omega^*)$. Since the terms of trade do not depend on government consumption, we get the effect on the foreign trade balance of a (tax-financed) home fiscal expansion as

currencies).

One can consider a different exchange rate $\tilde{e}$ on a hypothetical currency market that opens after the current state is known but before goods market opens. A different definition of the terms of trade can then be used, $\tilde{p} = \tilde{e}P_f^*/P_h$. In regimes without rationing of consumers, the terms of trade so defined equal the ratio of marginal utilities, $u_f(c_h, c_f)/u_h(c_h, c_f)$.

See Svensson (1985, Section 5) and Stockman and Svensson (1985) on the properties of these alternative definitions of terms of trade and exchange rates. In particular, the equilibrium of the model is the same if this additional currency market is added.

the subutility function.

$$(A3.3) \quad g = \left[\int_{j=0}^1 g_j^{\frac{(\eta_h-1)/\eta_h}{} dj \right]^{\eta_h/(\eta_h-1)}, \quad \eta_h > 1$$

of government g_j of differentiated home product j . The price index of home government consumption is

$$(A3.4a) \quad P_g = \left[\int_{j=0}^1 P_{hj}^{1-\eta_h} dj \right]^{1/(1-\eta_h)}$$

and the per capita home government demand for home product j will be

$$(A3.4b) \quad g_j = (P_{hj}/P_g)^{-\eta_h} g$$

Let $Y_j \leq y$ denote actual (per capita) output of home firm j . We specify that it is given by

$$(A3.5) \quad Y_j = \min(y, c_{hj} + g_j),$$

that is, the minimum of capacity and demand. Furthermore, let Q_{hj} denote the (per capita) home currency stock market value of home firm j . It is given by the asset-pricing equation (cf. (A2.3e))¹²

$$(A3.6a) \quad \lambda \pi_M Q_{hj} = \beta E[\lambda' \pi_M' (Q_{hj}' + P_{hj}' Y_j')],$$

which can be solved to give

$$(A3.6b) \quad Q_{hj} = P_{hj} E \left[\frac{\lambda' \pi_M'}{\lambda \pi_M} Y_j' \right] / \delta,$$

where δ , the rate of time preference, is given by $\beta = 1/(1+\delta)$. The expression for $\lambda' \pi_M' / \lambda \pi_M$, the marginal rate of substitution between nominal wealth in period t and $t+1$, can be simplified using (2.9) and (2.11d) which yields:

$$(A3.7) \quad \frac{\lambda' \pi_M'}{\lambda \pi_M} = \frac{1}{\omega'}.$$

Then the stock market value of home firm j can be written

¹² Note that whereas λ in (A2.3e) is the marginal utility of real wealth measured in home goods, $\lambda \pi_M$ in (A3.6a) is the marginal utility of nominal wealth, measured in home currency.

$$(A3.8) \quad Q_{hj} = P'_{hj} E[Y'_j/\omega']/\delta.$$

Home firm j chooses P'_{hj} to maximize (A3.8).

In equilibrium by symmetry all home firms will charge the same price P_{hj} . Then the price level P_h and the price index for government consumption will be equal,

$$(A3.9) \quad P_h = P_g.$$

Let $p_{hj} = P_{hj}/P_h$ denote the relative price of differentiated home product j , and exploit (A3.9) to define expected discounted sales $H(p_{hj}, k, k^*)$ according to

$$(A3.10) \quad H(p'_{hj}, k, k^*) = E[Y'_j/\omega'] = \\ = \int_{v'_h > 0} \frac{y'_j}{\omega'} dF(s') + \int_{v'_h = 0} \frac{p'^{-\sigma_h}_{hj} C_h(s', k, k^*) + p'^{-\eta_h}_{hj} g'}{\omega'} dF(s'),$$

where we have used (A3.5), (A3.2b), (A3.4b) and (2.14a). We now realize that maximization of (A3.8) implies that P'_{hj} is chosen such that the elasticity of expected discounted sales (A3.10) with respect to the relative price $p_{hj} = P_{hj}/P_h$ is set equal to minus unity. (This corresponds to choosing the marginal revenue equal to zero - recall that marginal cost is zero.) Furthermore, all home firms have identical demand. Hence they will all choose the same home currency price P_{hj} .¹³ Then we have

$$(A3.11) \quad P_{hj} = P_h, \quad P_{hj} = 1, \quad 0 \leq j \leq 1, \text{ and}$$

$$(A3.12) \quad - \frac{H_p(1, k, k^*)}{H(1, k, k^*)} = 1.$$

The first-order condition (A3.12) can by (A3.10) be written as

¹³ They will also choose the same output level, $Y_j = Y$, $0 \leq j \leq 1$, and in equilibrium consumers will consume the same quantity of home differentiated products, $c_{hj} = c_h = Y$.

$$(A3.13a) \quad \frac{\int_{v_h=0} \frac{\sigma_h C_h(s, k, k^*) + \eta_h g}{\omega} dF(s)}{H(1, k, k^*)} = 1.$$

By a completely symmetric argument, the first-order condition for foreign firms can be written

$$(A3.13b) \quad \frac{\int_{v_f^*=0} \frac{\sigma_f C_f(s, k, k^*) + \eta_f g^*}{\omega^*} dF(s)}{H^*(1, k, k^*)} = 1,$$

with obvious notation.

The first-order conditions (A3.13) have an intuitive interpretation. The home firm faces an ex post price elasticity of sales equal to a weighted average of σ_h and η_h when there is excess supply, that is when $v_h = 0$. It faces an ex post price elasticity of sales equal to zero when there is excess demand and full capacity, that is when $v_h > 0$. Since it must settle on a price for its output ex ante, it chooses the price so that the price elasticity of expected discounted sales equals unity. The latter is a weighted average of the ex post price elasticity when there is excess supply (the weighted average of σ_h and η_h) and the ex post price elasticity when there is excess demand (zero).

Now the full equilibrium is determined. The system (2.11) and (2.12) determines, for given k and k^* , the equilibrium consumption functions (2.14), and these together with the firms' first-order conditions (A3.13) determine the constants k and k^* .

A4. Elasticities of Substitution and the Derivation of (3.17)

From (3.16) we have

$$(A4.1) \quad u_h = U^{-1/\sigma} U_h \text{ and } u_f = U^{-1/\sigma} U_f. \text{ Furthermore,}$$

$$(A4.2) \quad U_h = U^{1/s} \gamma c_h^{-1/s} \text{ and } U_f = U^{1/s} (1-\gamma) c_f^{-1/s}. \text{ Then}$$

$$(A4.3a) \quad \epsilon u_h / \epsilon c_h = -(\epsilon U / \epsilon c_h) / \sigma + \epsilon U_h / \epsilon c_h \text{ and}$$

$$(A4.3b) \quad \epsilon u_h / \epsilon c_f = -(\epsilon U / \epsilon c_f) / \sigma + \epsilon U_h / \epsilon c_f, \text{ where}$$

$$(A4.4) \quad \epsilon U / \epsilon c_h = c_h U_h / U = \alpha_h \text{ and } \epsilon U / \epsilon c_f = c_f U_f / U = \alpha_f, \alpha_h + \alpha_f = 1.$$

Here α_h and α_f are the share of home and foreign goods in consumption expenditure.

Furthermore we have

$$(A4.5a) \quad \epsilon U_h / \epsilon c_h = (\epsilon U / \epsilon c_h) / s - 1/s = (\alpha_h - 1)/s = -\alpha_f/s \text{ and}$$

$$(A4.5b) \quad \epsilon U_h / \epsilon c_f = (\epsilon U / \epsilon c_f) / s = \alpha_f/s.$$

Combining this gives

$$(A4.6a) \quad \epsilon u_h / \epsilon c_h = -(\sigma \alpha_f + s \alpha_h) / \sigma s,$$

$$(A4.6b) \quad \epsilon u_h / \epsilon c_f = \alpha_f (\sigma - s) / \sigma s,$$

Now, differentiating (3.4c) to get the elasticity of the home goods partial consumption function (2.13a) with respect to consumption of foreign goods,

$\epsilon \tilde{C}_h / \epsilon c_f$, in region U, we get

$$(A4.7) \quad \frac{\epsilon \tilde{C}_h}{\epsilon c_f} = - \frac{\epsilon u_h / \epsilon c_f}{\epsilon u_h / \epsilon c_h} = \frac{\alpha_f}{\sigma \alpha_f + s \alpha_h} \sigma - \frac{\alpha_f}{\sigma \alpha_f + s \alpha_h} s = \frac{\alpha_f}{\sigma \alpha_f + s \alpha_h} (\sigma - s),$$

where we have used (A4.6). Since $\epsilon u_h / \epsilon c_f = c_f u_{hf} / u_h$ and $\epsilon u_h / \epsilon c_h < 0$, (3.17) follows.

It follows from (A4.7) that the elasticity of home goods consumption with respect to foreign goods consumption can be broken up into two terms of opposite signs, one having to do with intertemporal substitution (the term including σ), and one having to do with intratemporal substitution (the term including s). See Svensson and Wijnbergen (1986) for further discussion and a diagrammatic illustration of this.

Note also that from (A4.6a)

$$(A4.8) \quad \epsilon u_f / \epsilon c_f = -(\sigma \alpha_h + s \alpha_f) / \sigma s,$$

by symmetry. The assumption (3.3) by (A4.6a) implies

$$(A4.9) \quad \sigma > (1 - \alpha_f)s / (s - \alpha_f),$$

and the assumption (3.7a) by (A4.8) implies

$$(A4.10) \quad \sigma > (1 - \alpha_h)s/(s - \alpha_h).$$

It is easy to show that (A4.9) and (A4.10) together imply

$$(A4.11) \quad \sigma > s.$$

Note though that assumptions (3.3) and (3.7a) are only made in order to determine the relative location of the regions U, L and F (U^* , L^* and F^*) in (y, ω) and (y^*, ω^*) space. They are not necessary for the solution of the consumption functions (2.13) within each region. See Svensson (1986b) for details of the solution when (3.3) does not hold in a closed economy.

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Figure 1