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EXCHANGE RATE DYNAMICS AND FINANCIAL MARKET INTEGRATION

Alan Sutherland

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Centre for Economic Policy Research
25–28 Old Burlington Street
London W1X 1LB
Tel: (44 171) 878 2900

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1. Introduction

It is popularly believed that financial markets (and consequently goods and labour markets) are more turbulent now than they were in the 1950s and 1960s. It is also often asserted that this increase in volatility is a natural consequence of greater international capital mobility. The Dornbusch (1976) model of exchange rate dynamics appears to support this negative view of increased financial integration. The Dornbusch model suggests that freely operating foreign exchange markets will cause the nominal and real exchange rate to overshoot the long run equilibrium in response to a monetary shock. The real economy will consequently be destabilised by free capital mobility.

It is often argued, however, that *ad hoc* models, such as the Dornbusch model, do not take full account of the role of financial markets. Financial markets give economic agents the opportunity to substitute consumption and leisure intertemporally and to share risks. Increased financial market integration may therefore allow agents to deal more effectively with random shocks. Models based on intertemporally optimising agents (such as those analysed by Frenkel and Razin, 1987) would suggest that unambiguous benefits are to be gained by reducing barriers to the free movement of finance.

Typically general equilibrium models incorporating intertemporal optimisation are constructed on the basis of perfectly functioning goods and labour markets. One of the crucial mechanisms at work in the Dornbusch model, however, is the interaction between sluggish adjustment of goods prices and rapid adjustment in financial markets. It is the fact that goods prices cannot adjust instantly to clear the goods market that generates exchange rate overshooting. Intertemporal optimising models could therefore be giving a misleading picture of the effects of financial market integration because they are failing to take account of imperfections elsewhere in the economic system.

A recent paper by Obstfeld and Rogoff (1995) provides an ideal framework for considering this issue further. The Obstfeld and Rogoff model incorporates imperfect competition and sluggish price adjustment into an intertemporal optimising framework. It is therefore possible to analyse the interaction between financial integration and goods market imperfections while taking proper account of the role of financial markets in allowing intertemporal substitution.

Obstfeld and Rogoff modelled a two country world with perfect capital mobility[1] and nominal contracts which last for a single period. This paper takes the Obstfeld and Rogoff model as its basic framework and makes two modifications to allow more detailed consideration of financial market integration and sluggish price adjustment. Firstly, financial capital is made less than perfectly mobile across international boundaries. Secondly, multiperiod nominal contracts are introduced to allow varying degrees of nominal sluggishness to be considered.

Imperfect mobility of financial capital is modelled by assuming that a domestic agent can deal costlessly in the domestic financial market but is subject to convex costs of adjustment in the foreign financial market. Likewise, foreign agents can deal costlessly in the foreign financial market but are subject to adjustment costs in the domestic market. Differing degrees of financial integration can be represented by varying a parameter of the cost function. The extreme case of no costs clearly represents the case of perfect financial market integration between the two economies.[2]

To investigate the effects of varying the degree of market integration a log-linearised version of the model is calibrated and subjected to three forms of shocks: money supply, government purchases and labour supply. In each case the shock is perfectly asymmetric across the two countries. (The degree of financial market integration obviously has no implications for symmetric shocks since such shocks do not give rise to cross-border capital flows.) Both permanent and temporary shocks are considered.

The model is described in Section 2. In Section 3 the log-linearised version of the model is derived. Section 4 discusses the calibrated parameter values, describes the form of the shocks and presents the results. Section 5 concludes the paper.

1 The Obstfeld and Rogoff model assumes perfect capital mobility in the sense that there is no distinction between financial markets in different countries. Capital markets are, however, incomplete in the sense that agents do not have a full set of contingent assets to trade. Agents are therefore prevented from risk sharing to the extent that they might wish. Baxter and Crucini (1995) consider the implications of incomplete asset markets for open economy real business cycle models.

2 This paper clearly has connections with the literature on "international consumption risk sharing" and "home bias." The main theme of that literature is to show that low degrees of correlation between consumption levels in different countries and home bias in asset portfolios are not necessarily the result of imperfect capital mobility and transactions costs. This paper should not be interpreted as disputing the results of that literature. The purpose of this paper is to investigate the effects of reducing barriers to trade in financial markets when such barriers take the form of (convex) costs of transacting in foreign financial markets.

2. The Model

There are two equal sized countries each populated by consumers and producers. Consumers are identical so the analysis can proceed by considering a representative individual from each country. Each firm produces a single differentiated product and is indexed by z on the unit interval.

(i) Consumers and the goods market

The representative consumer in each country maximises a utility function which is defined over a CES basket of goods, C, real money balances, M/P, and labour supply, N. For the domestic consumer utility is given as follows

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{\sigma}{\sigma-1} C_s^{\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \left(\frac{M_s}{P_s} \right)^{1-\varepsilon} - \frac{\kappa_s}{\mu} N_s^{\mu} \right] \qquad (1)$$

where $0<\beta<1$, $\mu>1$ and $\sigma, \varepsilon>0$. Utility is defined identically for the foreign consumer. In what follows foreign variables are indicated by a star.

κ is a shock variable. An increase in κ represents an increase in the marginal disutility of labour and therefore a contraction in labour supply at a given wage.

The consumption index, C, is defined over all goods (both domestic and foreign produced) as follows

$$C = \left[\int_0^1 c(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} \qquad (2)$$

where $\theta>1$ and $c(z)$ is consumption of good z.

Purchasing power parity holds for each individual good so

$$p(z) = Ep^*(z) \qquad (3)$$

where $p(z)$ is the domestic currency price of good z, E is the nominal exchange rate (defined as the domestic currency price of foreign currency) and $p^*(z)$ is the foreign currency price of good z.[3]

It is assumed that goods indexed between 0 and 1/2 are domestically produced and goods indexed 1/2 and above are foreign produced. The general price index for domestic consumers, P, is therefore the following

$$P = \left[\int_0^1 p(z)^{1-\theta} dz \right]^{\frac{1}{1-\theta}} = \left[\int_0^{1/2} p(z)^{1-\theta} dz + \int_{1/2}^{1} Ep^*(z)^{1-\theta} dz \right]^{\frac{1}{1-\theta}} \quad (4)$$

PPP and identical preferences ensures that

$$P = EP^* \quad (5)$$

where P^* is the general price index for the foreign consumer.

(ii) Consumers and the financial market

The point at which this model departs from most other open economy general equilibrium models is in the structure of financial markets. The crucial assumption is that the financial markets in the two countries are imperfectly integrated. The domestic consumer can therefore hold wealth in three forms; domestic bonds (which are only traded in the domestic financial market), domestic money and foreign bonds (which are only traded in the foreign financial market).[4] The domestic consumer has free access to the domestic financial market. Hence holdings of domestic bonds can be adjusted without cost. Foreign asset holdings are, on the other hand, subject to costs of adjustment. Adjustment costs (in terms of the composite consumption good) are given by

$$Z_t = \frac{\psi}{2} I_t^2 \quad (6)$$

[3] There is clearly a major asymmetry between the way goods and financial markets are being treated in this model. The effects of the degree of integration of financial markets is being considered against the background of perfect goods market integration. If goods markets are not perfectly integrated purchasing power parity will not hold and firms might adopt a strategy of pricing to market. The interaction between goods and financial market integration in a model of this form is likely to be an interesting topic for further work.

[4] It is assumed that the domestic consumer does not receive any liquidity benefits from holding foreign currency. Foreign currency is therefore dominated by foreign bonds. The same assumptions apply to the foreign consumer as regards holdings of domestic currency.

where I is the level of funds (in terms of the composite consumption good) transferred from the domestic to the foreign bond market in period t. In a similar way, the foreign consumer has free access to the foreign bond market and is subject to adjustment costs in the domestic bond market.

The form of adjustment costs needs some justification. The most obvious form of adjustment costs in asset markets are charges such as broker's commission fees. Typically such fees are less than proportional to the size of transactions so large transactions benefit from economies of scale. Equation (6) on the other hand suggests diseconomies of scale in adjusting financial stocks. This is justified on the grounds that there are many costs other than broker's fees that arise in financial transactions and it is these other costs that are assumed to produce the convexity in equation (6). For instance, agents must devote time and resources to collecting information about investment opportunities. Also, in relation to dealing in foreign markets, agents must learn about procedures and regulations which may be very different from the home financial market. In addition to these factors, transmission and communication systems have a fixed capacity in the short run so attempts to transfer funds very rapidly in a short period of time will cause congestion costs. There are many reasons, therefore, to assume that the general technology that allows agents to transact in foreign financial markets suffers from decreasing returns to scale in the short run.[5]

Of course, with financial market integration, all the factors just listed are becoming less and less important in present day markets. (They may even be negligible in some markets.) The basic purpose of this paper is to represent the process of financial market integration by reducing the importance of adjustment costs. This is achieved by reducing the parameter ψ in the cost function. The simulation results reported in later sections therefore consider the implications of reducing ψ for the dynamics of the model.

Holdings of domestic bonds are denoted D (denominated in domestic currency) and holdings of foreign bonds are denoted F (denominated in foreign currency). The domestic consumer's holdings of domestic bonds evolve according to

$$\begin{aligned} D_t = (1+i_{t-1})D_{t-1} + M_{t-1} - M_t + w_t N_t \\ - P_t C_t - P_t I_t - P_t Z_t + \Pi_t - P_t T_t \end{aligned} \quad (7)$$

[5] See Christiano and Eichenbaum (1992) for a previous example where a portfolio allocation problem has been modelled with convex costs of adjustment.

where i is the nominal interest rate on domestic bonds, w is the nominal wage, Π is the consumer's share of profits of domestic firms and T is taxation. The evolution of foreign bond holdings is given by

$$F_t = (1 + i^*_{t-1})F_{t-1} + P^*_t I_t \tag{8}$$

The first order conditions relating to the consumer's maximisation problem are as follows

$$C_{t+1} = C_t \left[\beta (1 + i_t) \frac{P_t}{P_{t+1}} \right]^{\sigma} \tag{9}$$

$$c_t(z) = \left[\frac{p_t(z)}{P_t} \right]^{-\theta} C_t \tag{10}$$

$$\frac{\chi (M_t / P_t)^{-\varepsilon}}{C_t^{-1/\sigma}} = \frac{i_t}{1 + i_t} \tag{11}$$

$$\kappa_t N_t^{\mu-1} = C_t^{-1/\sigma} \frac{w_t}{P_t} \tag{12}$$

$$(1 + i_t)(1 + \psi I_t) = \frac{E_{t+1}}{E_t}(1 + i^*_t)(1 + \psi I_{t+1}) \tag{13}$$

An analogous set of conditions can be obtained for the foreign consumer. Equations (9), (10) and (11) are identical to those that arise in Obstfeld and Rogoff (1995). Equation (9) is the consumption Euler equation while equation (10) is the demand for individual product z. Equation (11) equates the marginal utility of real balances to the opportunity cost in terms of consumption.

Equation (12) is the labour supply rule which equates the marginal disutility of labour to the marginal utility of the real wage. There are assumed to be perfectly competitive, but separate, labour markets in each country. Thus migration from one country to the other is not possible. Nominal wages are determined by market clearing in the appropriate national labour market.

Equation (13) is the optimality condition relating to the allocation of

wealth between domestic and foreign bonds. In effect equation (13) equates the rates of return on domestic and foreign bonds after adjusting for the costs of transferring funds between markets. Notice that setting $\psi = 0$ reduces equation (13) to the standard uncovered interest parity condition. It is useful to note at this point that the equivalent optimality conditions for the foreign consumer is

$$(1 + i_t)(1 + \psi I^*_{t+1}) = \frac{E_{t+1}}{E_t}(1 + i^*_t)(1 + \psi I^*_t) \tag{14}$$

For obvious reasons the roles of the rates of return are reversed in this equation relative to equation (13).

(iii) The Government

The government in each country purchases goods in the form of the composite consumption good and finances expenditure using lump sum taxes and money printing. Thus

$$P_t G_t = P_t T_t + M_t - M_{t-1} \tag{15}$$

where G is purchases of the composite good. In what follows a government expenditure shock is assumed to be financed entirely by a change in taxes. A money supply shock is also assumed to lead to a corresponding change in T.

(iv) Firms

Firm z faces a demand for its product given by the following

$$y_t(z) = \left[\frac{p_t(z)}{P_t} \right]^{-\theta} Q_t \tag{16}$$

where $Q_t = [C_t + C^*_t + G_t + G^*_t + Z_t + Z^*_t]/2$. For simplicity it is assumed that output is equal to labour input.[6] Thus

[6] Obstfeld and Rogoff assume the capital stock is fixed so capital accumulation is not modelled. This assumption is retained in this paper. There are strong empirical (see Sachs, 1981) and theoretical (see Baxter and Crucini, 1993) arguments to suggest that capital accumulation is an important determinant of current account behaviour. Capital

$$y_t(z) = N_t(z) \tag{17}$$

where $N(z)$ is labour input in the production of product z. Period t profits are therefore given by

$$\frac{\Pi_t(z)}{P_t} = \frac{p_t(z)}{P_t}\left[\frac{p_t(z)}{P_t}\right]^{-\theta} Q_t - \frac{w_t}{P_t}\left[\frac{p_t(z)}{P_t}\right]^{-\theta} Q_t \tag{18}$$

In the absence of price rigidity the profit maximising price is given by $p_t(z) = w_t\,\theta/(\theta-1)$.

It is, however, assumed that firms are subject to sluggish price adjustment of the form described by Calvo (1983a, b). In this framework the number of periods between price adjustments for an individual firm is a random variable. To be specific, in each period a fixed proportion of firms, γ, will leave their prices at the level inherited from the previous period while the remaining $1-\gamma$ reset their prices to a new optimal level. Thus for an individual firm there is probability γ that it will not adjust its price in the current period and a probability $1-\gamma$ that it will. The presence of this form of price inertia makes the profit maximising problem more complex because the price set in the current period may have an impact on profits in future periods. A firm which does adjust its price level in period t will now maximise the discounted value of current and future profits with each future period weighted by the probability that the current price will still be in force in that period. Firm z's maximand is thus

$$V_t(z) = \sum_{s=t}^{\infty} \gamma^{s-t} R_{t,s} \frac{\Pi_s(z)}{P_s} \tag{19}$$

where R is the discount factor and is defined as follows

$$R_{t,s} = \left(\frac{1}{1+r_t}\right)\left(\frac{1}{1+r_{t+1}}\right)\left(\frac{1}{1+r_{t+2}}\right)\cdots\cdots\left(\frac{1}{1+r_s}\right) \tag{20}$$

and where r is the real interest rate. The first order condition for firm z is

accumulation is therefore likely to have important implications for the effects of financial market integration. This is an issue not pursued in this paper but it is likely to be a useful subject for further study.

$$p_t(z)(\theta-1)\sum_{s=t}^{\infty}\gamma^{s-t}R_{t,s}\frac{Q_s}{P_s}\left(\frac{1}{P_s}\right)^{-\theta} = \theta\sum_{s=t}^{\infty}\gamma^{s-t}R_{t,s}\frac{Q_s}{P_s}\left(\frac{1}{P_s}\right)^{-\theta} w_s \tag{21}$$

The structure of price setting implies that every firm that alters its price in period t chooses the same price level. The number of domestic firms which set their prices in period t is $(1-\gamma)$. So $(1-\gamma)$ firms set price p_t. Likewise the number of firms who last set their price in period $t-1$ is $(1-\gamma)\gamma$ so $(1-\gamma)\gamma$ firms have price level p_{t-1}. It is therefore possible to rewrite the definitions of the general price level for the domestic economy as

$$P_t = \left[\frac{1-\gamma}{2}\sum_{s=0}^{\infty}\gamma^s p_{t-s}^{1-\theta} + \frac{1-\gamma}{2}\sum_{s=0}^{\infty}\gamma^s (E_t p^*_{t-s})^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{22}$$

3. Log Linearisation

The model is log-linearised around an initial steady state where asset stocks and government expenditure levels are assumed to be zero. The steady state behaviour of the model is identical to the model described in Obstfeld and Rogoff (1995) so it is not discussed at length here. Steady state values of the main variables are given by the following equations

$$r_0 = \frac{1-\beta}{\beta} \tag{23}$$

$$\frac{w_0}{P_0} = \frac{\theta-1}{\theta} \tag{24}$$

$$y_0 = N_0 = C_0 = \left[\frac{\theta-1}{\theta\kappa_0}\right]^{\frac{\sigma}{\sigma(\mu-1)+1}} \tag{25}$$

$$\frac{M_0}{P_0} = \left[\frac{1-\beta}{\chi}\right]^{\frac{1}{\varepsilon}} y_0^{-\frac{1}{\sigma\varepsilon}} \tag{26}$$

Log deviations from the initial equilibrium are indicated by a hat. First consider the consumer's optimality conditions. Log-linearised versions of equations (9) to (13) are as follows

$$\frac{1}{\sigma}\left(\hat{C}_{t+1}-\hat{C}_t\right)=\hat{P}_t-\hat{P}_{t+1}+(1-\beta)\hat{i}_t \quad (27)$$

$$\hat{c}_t(z)=-\theta\left[\hat{p}_t(z)-\hat{P}_t\right]+\hat{C}_t \quad (28)$$

$$\hat{M}_t-\hat{P}_t=\frac{1}{\sigma\varepsilon}\hat{C}_t-\frac{\beta}{\varepsilon}\hat{i}_t \quad (29)$$

$$\hat{N}_t=\frac{1}{\mu-1}\left[\hat{w}_t-\hat{P}_t-\frac{1}{\sigma}\hat{C}_t-\hat{\kappa}_t\right] \quad (30)$$

$$(1-\beta)\hat{i}_t+\frac{\psi}{\beta}\hat{I}_t=\hat{E}_{t+1}-\hat{E}_t+(1-\beta)\hat{i}^*_t+\frac{\psi}{\beta}\hat{I}_{t+1} \quad (31)$$

Log-linearising equation (14) yields

$$(1-\beta)\hat{i}_t+\frac{\psi}{\beta}\hat{I}^*_{t+1}=\hat{E}_{t+1}-\hat{E}_t+(1-\beta)\hat{i}^*_t+\frac{\psi}{\beta}\hat{I}^*_t \quad (32)$$

In equations (31) and (32) the variables $\hat{I}$ and $\hat{I}^*$ are defined as I/C_0 and I^*/C_0 respectively.[7]

Turn now to the price setting condition given by equation (21). Log-linearising yields

$$\hat{p}_t(z)+(1-\beta\gamma)\sum_{s=t}^{\infty}(\beta\gamma)^{s-t}\hat{x}_s = \frac{\theta}{\theta-1}\frac{w_0}{P_0}(1-\beta\gamma)\sum_{s=t}^{\infty}(\beta\gamma)^{s-t}(\hat{x}_s+\hat{w}_s) \quad (33)$$

where $\hat{x}_s=\hat{Q}_s-(1+\theta)\hat{P}_s$. Leading this equation by one period and then subtracting yields

[7] The steady state values of I and I^* are zero so the log deviations can not be used.

$$\hat{p}_t(z)-\beta\gamma\hat{p}_{t+1}(z)=(1-\beta\gamma)\hat{w}_t \quad (34)$$

where use has been made of the fact that $w_0/p_0=(\theta-1)/\theta$.

Log-linearising the definition of the general price index given in equation (22) yields

$$\hat{P}_t=\frac{1-\gamma}{2}\sum_{s=0}^{\infty}\gamma^s\hat{p}_{t-s}+\frac{1}{2}\hat{E}_t+\frac{1-\gamma}{2}\sum_{s=0}^{\infty}\gamma^s\hat{p}^*_{t-s} \quad (35)$$

It is convenient to define two further price indexes as follows

$$\hat{q}_t=(1-\gamma)\sum_{s=0}^{\infty}\gamma^s\hat{p}_{t-s} \quad \text{and} \quad \hat{q}^*_t=(1-\gamma)\sum_{s=0}^{\infty}\gamma^s\hat{p}^*_{t-s} \quad (36)$$

which can be thought of as indexes of the general prices of domestically and foreign produced goods respectively. The general price index of all goods can therefore be written as

$$\hat{P}_t=\frac{1}{2}\hat{q}_t+\frac{1}{2}\left[\hat{E}_t+\hat{q}^*_t\right] \quad (37)$$

It is simple to derive the following expression for the evolution of $\hat{q}$

$$\hat{q}_t-\gamma\hat{q}_{t-1}=(1-\gamma)\hat{p}_t \quad (38)$$

A similar equation defines the evolution of $\hat{q}^*$.

Log-linearising equation (15) and aggregating across all domestic firms yields the following expression for aggregate output of the domestic economy

$$\hat{y}_t=\hat{Q}_t-\theta\left[\hat{q}_t-\hat{P}_t\right] \quad (39)$$

Finally consider the evolution of asset stocks. First note that by definition $w_tN_t+\Pi_t=q_ty_t$ so log-linearising equation (7) (after first substituting for M_{t-1}-M_t using the government's budget constraint) yields

$$\hat{D}_t=\frac{1}{\beta}\hat{D}_{t-1}+\hat{q}_t+\hat{y}_t-\hat{P}_t-\hat{C}_t-\hat{I}_t-\hat{G}_t \quad (40)$$

The log-linear version of the model is completed by log-linearising equation (8) to yield

$$\hat{F}_t = \frac{1}{\beta}\hat{F}_{t-1} + \hat{I}_t \qquad (41)$$

In equations (40) and (41) the variables $\hat{D}$, $\hat{G}$ and $\hat{F}$ are defined as D/C_0, G/C_0 and F/C_0 respectively.[8]

4. Asymmetric Shocks

The dynamics of the model are investigated by simulating a calibrated version of the log-linear system. The model is subjected to shocks from three sources: the money supply, government purchases and labour supply. In each case deterministic dynamic solution paths are presented for different degrees of financial market integration. The effects of different degrees of price stickiness are also investigated. Only asymmetric shocks are considered because agents in different countries (at least in this model) only want to trade in international financial markets if the two countries are affected by different shocks. In other words, symmetric shocks do not give rise to international financial flows so financial market integration has no effect on the model's response to symmetric shocks.

The shock variables for the domestic economy (measured in terms of log deviations from equilibrium values) evolve according to the following equations

$$\hat{M}_t = \rho\hat{M}_{t-1} \qquad (42)$$

$$\hat{G}_t = \alpha\hat{G}_{t-1} \qquad (43)$$

$$\hat{\kappa}_t = \eta\hat{\kappa}_{t-1} \qquad (44)$$

In each case the value of the variable is shocked away from its equilibrium

[8] Again this is because the steady state values of D, G and F are zero so log deviations can not be used.

value by plus 1 percent in period 1. In the case of permanent shocks ρ, α and η are all set at unity so there is no subsequent change in the shock variable. In the case of temporary shocks ρ, α and η are set at a value between zero and unity. After the initial period the shock variables therefore converge back to their equilibrium values. In each case the corresponding foreign variable is shocked by minus 1 percent in period 1. Other then this difference of sign the foreign shock variables share the same dynamics as the domestic shock variables.

The calibrated parameter values used in the simulations are listed in Table 1. Most of these values are taken from Hairault and Portier (1993). The Hairault and Portier model has the same imperfect competition structure as the model of this paper and it models money demand in approximately the same way. There is therefore a direct correspondence between many of the parameters. In the case of money demand the parameter ε is chosen to yield the same nominal interest rate elasticity of money demand as in the Hairault and Portier model. In the case of goods supply the parameter μ is chosen to yield the same relationship between goods supply and utility as in the Hairault and Portier model.[9]

Table 1: Parameter Values

β=1/1.05	ε=9.0	μ=1.4	σ=0.75	θ=6.0	ρ=α=η=0.5

The parameters ρ, α and η are all set at 0.5 in the case of temporary shocks. This value is simply chosen to illustrate the properties of the model and is not based on any empirical results.[10]

[9] In the Hairault and Portier model the production function is Cobb-Douglas in capital and labour while the utility of the representative consumer is linear in work effort. If the labour share is (1-a) then (assuming capital is fixed) the utility function of the representative agent contains a linear term in $y^{1/(1-a)}$ (after substituting the inverted production function into the utility function). In the model of this paper output is linear in labour input. Substituting the production function into the utility function yields a linear term in y^{μ}. Thus the parameter μ can be obtained from the relationship $\mu = 1/(1-a)$. This yields a value of 1.4 (rounded to the first decimal place) for μ given Hairault and Portier's value of 0.3 for a.

[10] Note that the parameter χ does not appear in the linearised version of the model.

The parameter ψ, which measures the degree of financial market integration, and the parameter γ, which measures the degree of price stickiness, are chosen to illustrate different cases in the simulations reported below. Perfect financial market integration is represented by ψ=0 while imperfect market integration is illustrated with ψ=5. The degree to which this segments financial markets will be measured by considering capital flows in the different simulations. γ is set at 0.5 as a benchmark value. This represents an average delay between price adjustments of 2 periods. The effects of setting γ to 0.75 and 0.25 are also illustrated. Setting γ=0.75 raises the average period between price adjustments to 4 periods while setting γ=0.25 reduces the average period between price adjustments to 1.33.

(i) Money supply shocks

The dynamic response to a permanent shock to the money supply is illustrated in Figure 1. In this case the money supply of the domestic country is increased by 1 percent and the money supply in the foreign country is reduced by 1 percent. In each panel there are two plots. The plot marked with dots is the case of perfect capital mobility (ψ=0) and the plot marked with crosses is the case of imperfect capital mobility (ψ=5). Only variables for the domestic economy are illustrated. The response of the foreign economy is a mirror image of the domestic economy.

First consider the case of perfect capital mobility. With perfectly integrated financial markets there is effectively only one interest rate. A perfectly asymmetric shock always implies that the quantity of funds domestic agents want to lend (or borrow) is always identical to the quantity of funds foreign agents want to borrow (or lend). As a result asymmetric shocks do not change interest rates. This is confirmed in the last two panels of Figure 1 which show the dynamic response of nominal and real interest rates. It is easy to see from the consumption Euler equation (equation (27)) that the response of domestic consumption to the money supply shock must be a once-and-for-all step change to a new long run level. This is confirmed in the first panel of Figure 1.

The effect of the monetary shock on the exchange rate can be determined by considering the money market equilibrium condition in equation (29). Subtracting the foreign equilibrium condition for this equation yields

$$\hat{M}_t - \hat{M}^*_t - \hat{E}_t = \frac{1}{\sigma\varepsilon}\left[\hat{C}_t - \hat{C}^*_t\right] - \frac{\beta}{\varepsilon}\left[\hat{i}_t - \hat{i}^*_t\right] \qquad (45)$$

Here use has been made of the purchasing power parity condition to substitute for relative price levels. The shock to relative money supplies is a once-and-for-all step change. It has just been argued that the shock to relative consumption levels is also a once-and-for-all step change and that nominal interest rates are identical in the two countries. Equation (45) demonstrates that the exchange rate must also make a once-and-for-all step change in response to the monetary shock. This is confirmed in Figure 1 where it is shown that the exchange rate depreciates by approximately 2 percent in response to the money supply shock.

The fact that the nominal exchange rate depreciates while nominal prices are sticky in the short run must imply that the relative price of domestically produced goods falls in the short run. Equation (39) (the demand function for domestic goods) predicts that a fall in relative prices must result in a rise in domestic output. Again this is confirmed in Figure 1. The money supply shock produces an expansion of domestic output of over 1.5 percent in period 1. As nominal contracts are renewed nominal prices increase and relative prices move back towards their original level. Output therefore also converges to its original level.

It is thus the case that domestic agents have high income in the short run while they maintain a flat consumption profile. They must therefore be saving and accumulating bonds. This is shown in Figure 1 panel (d). The long run effect of bond accumulation is that domestic agents have a higher wealth stock. This allows them to consume more and work less in the long run. Hence the slight fall in long run output revealed in Figure 1.[11]

Turn now to the case with imperfect capital mobility. The central implication of imperfect capital mobility is that domestic and foreign bonds become differentiated and can therefore pay different rates of return. The fact that domestic agents are attempting to accumulate assets (and therefore offering funds to lend in the domestic bond market) drives down domestic interest rates. This is shown in the last two panels of Figure 1. There is a corresponding rise in foreign interest rates and domestic consumers are induced to move funds into the foreign market. But the accumulation of foreign bonds is much reduced compared to the case of free capital mobility. The long run stock of foreign bonds is approximately 20% of

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[11] All the effects just described are identical to those described by Obstfeld and Rogoff (1995). The full integration case in this model is identical to their model except for the extra dynamics introduced by multiperiod contracts.

the level in the free capital mobility case.

The fall in domestic interest rates creates an incentive for domestic consumers to bring consumption forward in time. The first panel in Figure 1 shows that consumption rises sharply in period 1 and thereafter declines. Not surprisingly, in the absence of efficient ways of accumulating financial wealth, consumption follows the time profile of income very closely.

The behaviour of the exchange rate can again be explained with reference to equation (45). The consumption differential is much more strongly positive in the imperfect capital mobility case while the interest differential becomes negative. Both effects imply that the exchange rate should not depreciate as much as in the perfect capital mobility case. This is confirmed in Figure 1.[12] The fact that the exchange rate depreciates by less in turn implies that the relative prices of domestic goods fall by less and domestic output rises by less.

In summary, the results reported in Figure 1 show that increasing financial integration reduces the impact of asymmetric monetary shocks on interest rates but increases the short run impact on the nominal (and real) exchange rate. As a consequence output is more volatile with integrated markets. Consumption, on the other hand, is less volatile because integrated financial markets provide more opportunities for consumption smoothing.

The case of a temporary monetary shock is illustrated in Figure 2. The overall conclusion is approximately the same as in the case of permanent shocks. The only major difference is that the short run is relatively much more important. The short run destabilisation of the exchange rate and output caused by financial market integration is now much more significant; as is the stabilisation of consumption.

(ii) Goods demand shocks

The effect of a permanent asymmetric shock to government purchases is shown in Figure 3. In this case the domestic government increases expenditure by 1 percent and the foreign government reduces expenditure by 1 percent. The changes are financed by lump sum taxes on consumers (i.e. domestic consumers pay more tax while foreign consumer pay less).

12 Obstfeld and Rogoff noted that their model did not produce exchange rate overshooting of the type demonstrated by the Dornbusch (1976) model. The results shown in Figure 1 demonstrate that this continues to be true when capital is less than perfectly mobile.

As in the case of monetary shocks, an asymmetric demand shock has no impact on nominal and real interest rates when there is perfect capital mobility. In turn this implies that the consumption response must be a once-and-for-all step change. Domestic consumers have a higher tax bill after the shock so domestic consumption falls (by just over 0.34 percent as shown in the first panel of Figure 3).

Equation (45) can again be used to explain the behaviour of the nominal exchange rate. Relative money supplies and nominal interest rates have not changed following the shock while the relative consumption level of domestic consumers has declined. The nominal exchange rate therefore depreciates. Panel (c) in Figure 1 shows a once-and-for-all depreciation of the exchange rate of 0.1 percent.

Nominal prices are sticky in the short run so a nominal depreciation lowers the relative price of domestic goods. Domestic output therefore expands. Output also expands because of the supply side effect of the shock. The tax increase represent a negative wealth effect on domestic consumers. They therefore decrease their consumption of goods and leisure, i.e. labour supply expands. This is reflected in a higher long run level of output.

Output rises slightly less in the short run than in the long run. The flat consumption profile therefore implies some debt accumulation by domestic consumers in the short run. This is shown in panel (d) of Figure 1.

Consider now the implications of imperfect capital mobility. As just explained, the shock causes domestic consumers to accumulate debt. When financial markets are not perfectly integrated debt accumulation must force up the interest rate in the domestic financial market. This is confirmed in the last two panels of Figure 3. High real interest rates in the short run create an incentive for domestic consumers to shift consumption into the future, i.e. they adopt a rising consumption profile. This is confirmed in the first panel of Figure 3.

Equation (45) can again be used to analyse the response of the nominal exchange rate. Domestic interest rates have risen while relative consumption levels have fallen by more than in the perfect capital mobility case. The exchange rate must therefore depreciate by more in the short run. The is confirmed in panel (c) of Figure 3. In turn a greater depreciation of the nominal exchange rate causes output to expand by more in the short run (panel (b) Figure 3). Consumption and output now follow similar paths so the consumer accumulates less debt (panel (d) Figure 3). As in the previous cases, imperfect capital mobility results in a steady state debt level which is about 20 percent of the perfect capital mobility case.

In summary it can be seen from Figure 3 that financial market integration stabilises all variables (except debt levels) in response to a demand shock in the sense that the short run impact of the shock is smaller when there is perfect capital mobility.

The effects of a temporary demand shock are not shown. Given the assumption of lump sum taxation the timing of government purchases and taxation is irrelevant to the consumers' maximisation decisions. A temporary shock to government purchases therefore produces exactly the same effects as a permanent shock (when the size of the permanent shock is chosen to yield the same discount value of taxation).

(iii) Labour supply shocks

The effects of permanent shocks to labour supply are shown in Figure 4. In this case the parameter κ is increased by 1 percent for the domestic consumer and decreased by 1 percent for the foreign consumer. The domestic consumer therefore wants to supply less labour while the foreign consumer wants to supply more.

As in all previous cases the perfectly asymmetric shock has no effect on interest rates when there is perfect capital mobility. Consumption therefore makes a once-and-for-step change in response to the shock. The reduction in labour supply not surprisingly leads to a long run reduction in output. Consumers therefore also reduce consumption.

Equation (45) explains the effect on the nominal exchange rate. Interest rates and money supplies are unaffected by the shock while domestic consumption has declined relative to foreign consumption. The exchange rate therefore depreciates. As in previous cases with perfect capital mobility the depreciation takes the form of a once-and-for-all step change.

The depreciation combined with sticky nominal prices implies that home goods prices fall relative to foreign goods prices in the short run. This tends to offset the contraction in domestic output in the short run. Output declines towards its new long-run level as contracts are renewed and nominal prices adjust to the shock. The fact that output is relatively higher in the short run while consumption falls allows domestic residents to accumulate assets.

Now consider the effects of imperfect capital mobility. The desire by domestic consumers to accumulate assets tends to drive down domestic interest rates. This is shown in the last two panels of Figure 4. In turn this implies that consumers bring consumption forward in time. Consumption therefore falls by less in the short run compared to the

perfect capital mobility case. Equation (45) shows that lower interest rates and higher consumption lead to a smaller depreciation of the nominal exchange rate in the short run. This is confirmed in panel (c) of Figure 4. Domestic goods prices therefore fall by less than in the perfect capital mobility case and output contracts by more. Panel (d) in Figure 4 shows that again the effect of imperfect capital mobility is to reduce the steady state stock of foreign assets to approximately 20 percent of its value in the perfect capital mobility case.

The overall effect of moving to perfect capital mobility in the face of permanent labour supply shocks is to increase the short run volatility of output and nominal and real exchange rates but to reduce the short run volatility of consumption and the nominal exchange rate.

The effects of temporary labour supply shocks are illustrated in Figure 5. In contrast to the cases of monetary and demand shocks, there are major differences between temporary and permanent labour supply shocks. Consider first the effects of a temporary shock when there is perfect capital mobility. A temporary shock implies that output is low in the short run relative tō the long run. The domestic consumer therefore will want to accumulate debt in the short run in order to smooth consumption. This is exactly the opposite of what occurs with a permanent labour supply shock.

Turn now to the effects of a temporary shock when there is imperfect capital mobility. In this case a temporary labour supply shock causes domestic interest rates to rise because domestic consumers are attempting to borrow. In turn this induces domestic consumers to shift consumption into the future. Equation (45) therefore shows that the nominal exchange rate must depreciate more in the short run than in the perfect capital mobility case (panel (c) Figure 5). Thus, in the short run while prices are sticky, domestic output falls by less.

The overall result, in the case of temporary labour supply shocks, is that interest rates, consumption, and the nominal exchange rate are more stable when capital is perfectly mobile while output is less stable.

(iv) Varying the degree of price inertia

A crucial feature of the Dornbusch (1976) model is the interaction between sluggish price adjustment in goods markets and high capital mobility. It is therefore interesting to investigate the implications of the degree of price sluggishness for the results just presented.

Table 2 lists the impact effects of the different shocks for different values of the parameter γ. (To save space only permanent shocks are considered.) γ is the probability that an individual firm will not adjust its price in the current period so a lower value of γ implies prices are more flexible while a higher value implies more inertia. The benchmark value of γ=0.5 yields an average delay between price adjustments of 2 periods. Table 2 shows the effects of lowering γ to 0.25 which implies an average delay of 1.33 periods between adjustments. The effects of raising γ to 0.75 are also shown. This implies an average delay of 4 period between adjustments. For each variable and for each value of γ the impact effect of the shock is shown for both the perfect capital mobility case (ψ=0) and the imperfect capital mobility case (ψ=5).

Table 2: Impact effects and price inertia

(i) Permanent money shocks

γ	C		y		E		i		R	
0.25	0.00	0.13	0.60	0.25	2.00	1.77	0.00	-0.04	0.00	-0.15
0.50	0.03	0.32	1.67	0.62	1.99	1.47	0.00	-0.10	0.00	-0.27
0.75	0.11	0.64	3.32	1.22	1.97	1.14	0.00	-0.15	0.00	-0.31

(ii) Permanent demand shocks

γ	C		y		E		i		R	
0.25	-0.34	-0.35	0.74	0.77	0.10	0.12	0.00	0.00	0.00	0.01
0.50	-0.34	-0.36	0.66	0.74	0.10	0.14	0.00	0.01	0.00	0.02
0.75	-0.35	-0.39	0.52	0.69	0.10	0.17	0.00	0.01	0.00	0.03

(iii) Permanent labour supply shocks

γ	C		y		E		i		R	
0.25	-0.50	-0.47	-0.50	-0.55	0.15	0.11	0.00	-0.01	0.00	-0.02
0.50	-0.49	-0.44	-0.31	-0.49	0.14	0.06	0.00	-0.02	0.00	-0.05
0.75	-0.48	-0.38	-0.02	-0.38	0.14	0.00	0.00	-0.03	0.00	-0.06

C= domestic consumption, y=domestic output, E=nominal exchange rate, i=domestic nominal interest rate, R=domestic real interest rate
Each row corresponds to a value of γ. For each variable there are two columns, the first is for ψ=0 and the second for ψ=5.

Table 2 shows that the impact of monetary shocks on real variables declines as the degree of price inertia decreases. This is exactly what should be expected. In the absence of price inertia the classical dichotomy holds in this model. A monetary shock produces an equal percentage change in all nominal variables and leaves real variables unchanged. Notice when price inertia is low the exchange rate depreciates by 2 percent in response to the monetary shock (remember that the domestic money supply expands by 1 percent and the foreign money supply contracts by 1 percent so the combined movement in relative nominal goods prices is 2 percent).

Demand and labour supply shocks have permanent real effects even when there are no price rigidities. In these cases price inertia tends to prevent real variables from adjusting quickly to their new long run levels. The impact effects shown in Table 2 therefore decline as the degree of price inertia increases.

The main feature of interest in Table 2 is the interaction between price inertia and capital mobility. In all cases it can be seen that the difference between perfect and imperfect capital mobility increases as the degree of price inertia increases. This is most pronounced for monetary shocks. When price inertia is high (γ=0.75) moving from imperfect to perfect capital mobility more than doubles the impact effect of a monetary shock on output and almost doubles the effect on the nominal exchange rate.

The link between price inertia and capital mobility is straightforward to explain. The major implication of imperfect capital mobility is that it makes intertemporal substitution more difficult. This is more important when shocks have intertemporal effects on output. The main implication of price inertia is that it slows down the response of output to shocks. Therefore, the higher the degree of price inertia, the more agents want to use financial markets to smooth consumption. Hence imperfect capital mobility is more important when prices are sticky. Or, to put the result another way, the integration of financial markets will have a more significant impact when prices are sticky.

5. Conclusion

This paper has analysed the effects of integration of financial markets in a two country intertemporal general equilibrium model with imperfect competition and nominal inertia. The general picture that emerges is that, with a few exceptions, increasing financial market integration tends to decrease short run volatility. The main exception to this rule is the case of monetary shocks. Here financial integration tends to increase the short run volatility of the nominal exchange rate and output. Yet even in this case financial integration reduces the volatility of nominal and real interest rates and consumption. Thus the analysis of this paper shows that some of the conclusions of the Dornbusch (1976) model do carry over to a more general model. But there are many important cases where they do not.

The model presented in this paper can be improved in a number of directions. For instance, there are strong empirical and theoretical arguments for supposing that current account behaviour is driven in large part by capital accumulation (see Sachs (1981) and Baxter and Crucini (1993)). The behaviour of capital stocks is therefore likely to have important implications for the effect of financial market integration. Other important modifications to the model must include relaxing the assumption of perfect goods market integration so that pricing to market behaviour can be introduced.

Another direction of improvement is in the measurement of welfare. This paper has, in effect, used volatility as a measure of welfare. The underlying assumption is that greater volatility is bad for welfare. Of course, a truer measure of welfare is provided by the level of utility enjoyed by consumers. This paper has not explicitly considered the effects of increasing financial market integration on utility since simulations of a linearised model are not well suited to such a task. Another important extension of this analysis would therefore be a more rigorous analysis of welfare effects.

There is one final point which should emphasised. This paper has considered the general equilibrium effects of increasing capital mobility. This not the only way to analyse the effects of market integration. It may be that market micro structure is much more important in determining the effects of greater integration. The day to day interaction between agents in financial markets may give rise to forces which far outweigh the effects identified in this paper.

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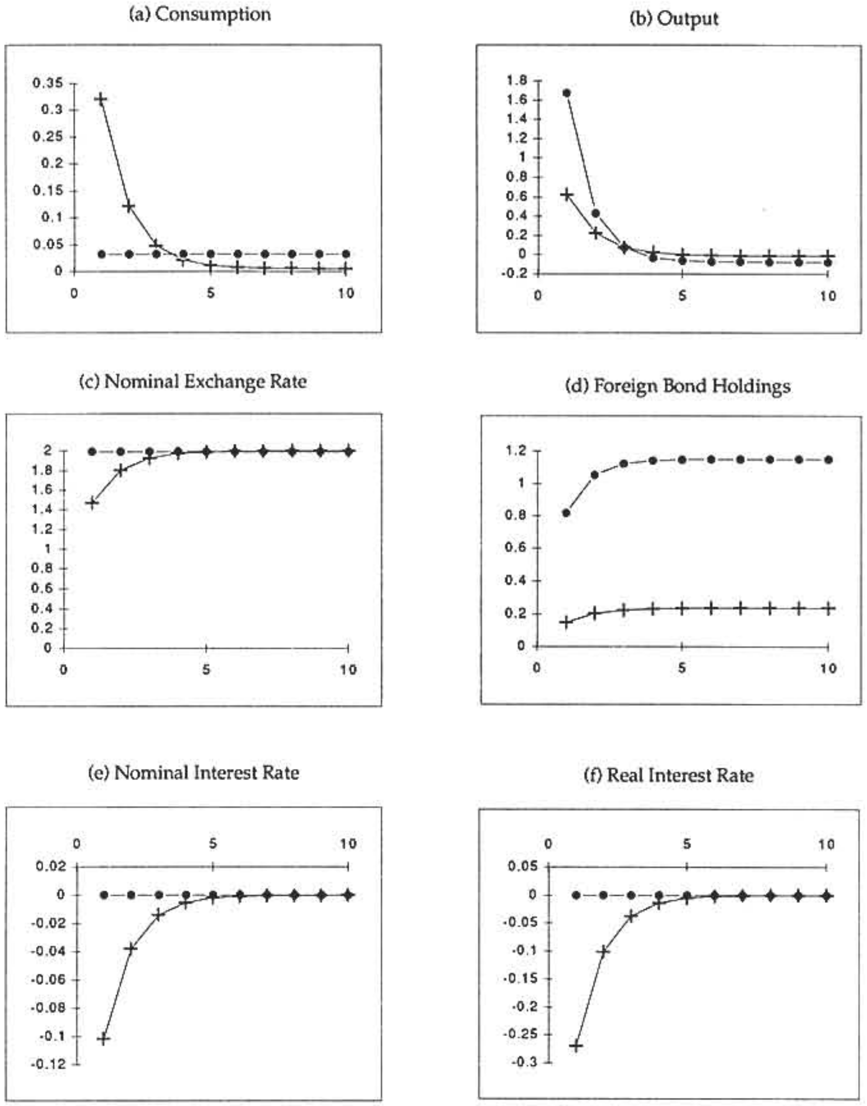
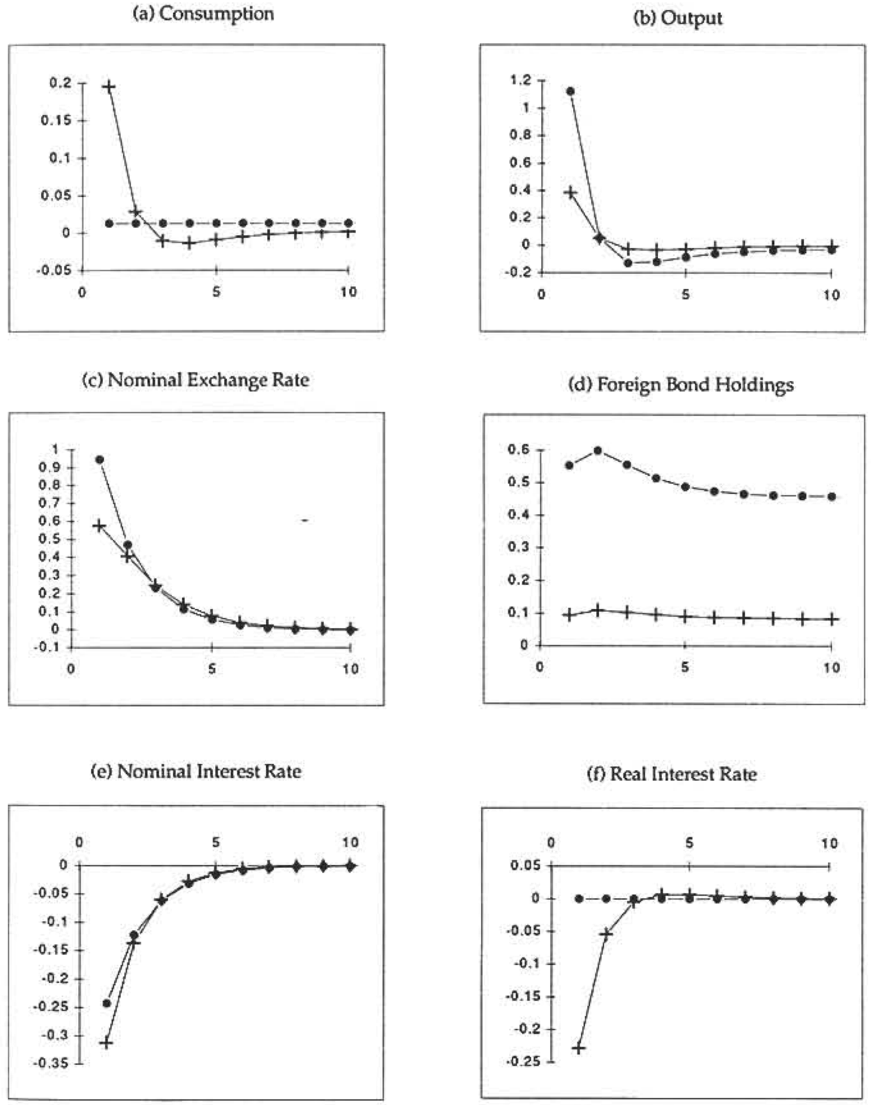
Figure 1: Permanent Shock to the Money Supply



• Perfect capital mobility + Imperfect capital mobility

Units of measurement:
Consumption, output and the nominal exchange rate - Percentage deviation from initial equilibrium
Bond holdings - Deviation as percentage of initial consumption level
Interest rates - Percentage point deviation from initial equilibrium

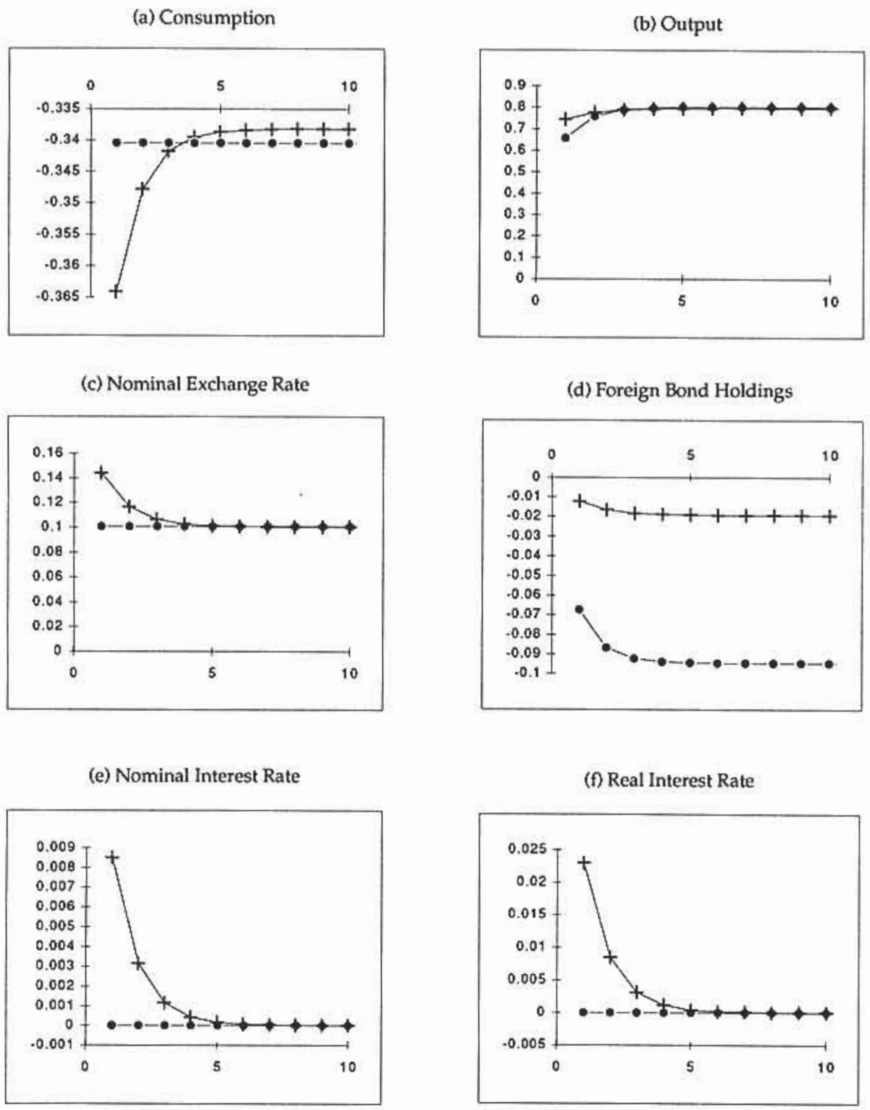
Figure 2: Temporary Shock to the Money Supply



• Perfect capital mobility + Imperfect capital mobility

Units of measurement:
Consumption, output and the nominal exchange rate - Percentage deviation from initial equilibrium
Bond holdings - Deviation as percentage of initial consumption level
Interest rates - Percentage point deviation from initial equilibrium

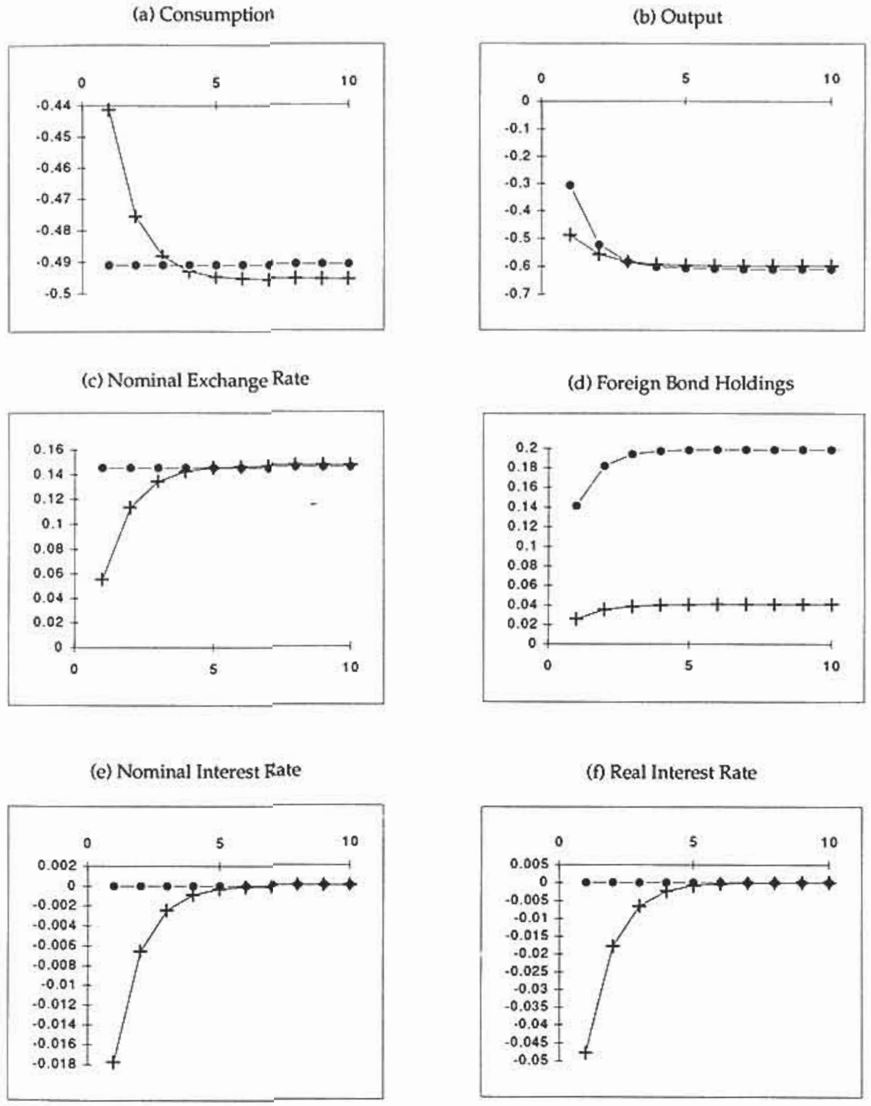
Figure 3: Permanent Shock to Government Purchases



• Perfect capital mobility + Imperfect capital mobility

Units of measurement:
Consumption, output and the nominal exchange rate - Percentage deviation from initial equilibrium
Bond holdings - Deviation as percentage of initial consumption level
Interest rates - Percentage point deviation from initial equilibrium

Figure 4: Permanent Shock to Labour Supply



• Perfect capital mobility + Imperfect capital mobility

Units of measurement:
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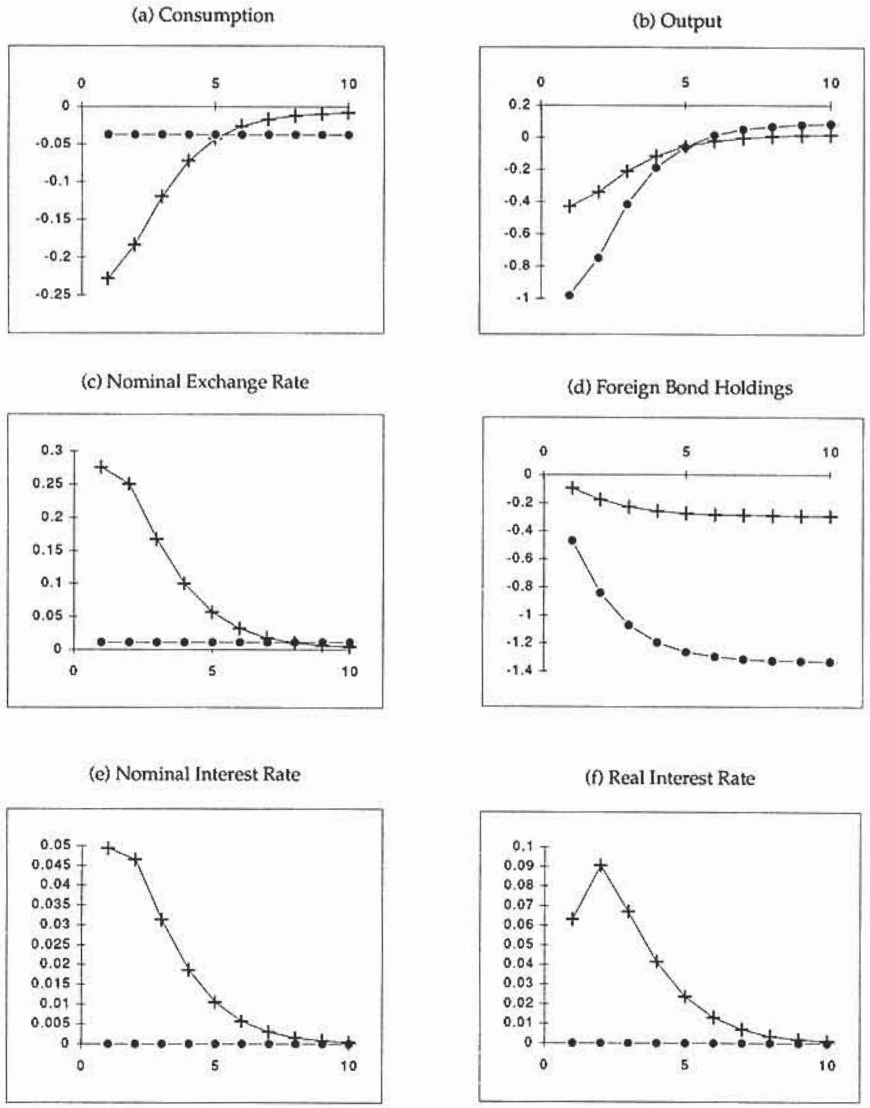
Bond holdings - Deviation as percentage of initial consumption level
Interest rates - Percentage point deviation from initial equilibrium

Figure 5: Temporary Shock to Labour Supply



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