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This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

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INTERNATIONAL FINANCIAL INTERMEDIATION AND AGGREGATE FLUCTUATIONS UNDER ALTERNATIVE EXCHANGE RATE REGIMES*

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Abstract

This paper presents a two-country overlapping generations model in which financial intermediation arises endogenously as an incentive-compatible means of economizing on monitoring costs. Because of the existence of transactions costs, money markets in the two countries are segmented and investors have differential access to international credit markets. The model is used to generate predictions about the role of international intermediation in determining the nature of business cycle phenomena across alternative exchange rate regimes. Disturbances are propagated by a credit allocation mechanism, which also lends a novel flavor to the model's long-run properties.

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1. Introduction

Though financial intermediaries that borrow and lend internationally play an important role in providing capital mobility, studies of the effects of capital mobility on international business cycle phenomena typically do not include an explicit treatment of the intermediation process. However, work by Boyd and Prescott (1986), Diamond (1984), and Williamson (1986), among others, has made some progress by developing explicit theories of financial intermediation, and these theories have been applied in macroeconomic settings by Bernanke and Gertler (1988) and Williamson (1987). The purpose of this paper is to construct a model where equilibrium financial arrangements involve international financial intermediation and trading in country-specific monies, and to use this model to study the relationships among financial structure, business cycle phenomena, and the exchange rate regime.

A two-country overlapping generations model is constructed in which financial intermediation arises endogenously as an incentive-compatible means for economizing on the costs to lenders of monitoring borrowers [as in Williamson (1986, 1987)]. The model captures the important characteristics of real-world intermediaries in that these intermediaries write debt contracts with borrowers; they borrow from and lend to large numbers of agents; and they carry out an asset transformation, making noncontingent payments to their depositors.

In the model, trade in goods and assets is unrestricted. In particular, capital is perfectly mobile, with nothing inhibiting financial intermediation across international boundaries. The only constraint on private behavior is a portfolio restriction that bans the holding of the other country's currency from one period to the next. Agents in each country have different degrees of access to international capital markets because of the existence of transactions costs. In equilibrium, the composition of agents' portfolios differs: some hold their own country's currency, while others hold intermediary deposits backed by a diversified portfolio of loans made to agents in both countries.

In a deterministic version of the model, higher money growth and inflation are associated with higher per capita income because of portfolio substitution and a credit allocation mechanism which provides a direct link from credit and investment to output. A one-time improvement in the investment technology common to both countries results in increases in the quantity of intermediated credit, real interest rates, and income, with the world economy becoming less monetized.

Business cycle fluctuations due to technological and monetary disturbances are examined under three alternative exchange rate regimes: a <u>flexible exchange rate regime</u> and two regimes with a fixed exchange rate. The first fixed exchange rate regime is a <u>fiscal policy peg</u>, where monetary policy is held constant; the second fixed exchange rate regime is a <u>monetary policy peg</u>, where fiscal policy is held constant. The evidence in Mitchell (1928), Morgenstern (1959), and Klein and Moore (1985), using National Bureau of Economic Research methodology, and the evidence in Backus and Kehoe (1988) using conventional summary statistics, indicates a high degree of synchronization in business cycle behavior among groups of countries with close financial ties.[1] This is the case in the model developed here; national outputs, interest rates, and inflation rates are positively correlated across countries under <u>all</u> the exchange rate systems considered. Consistent with conventional views, interest rates are procyclical in response to real shocks and countercyclical in response to monetary shocks, with the inflation rate exhibiting the opposite cyclical pattern.

Though business cycle phenomena are qualitatively similar across exchange rate regimes, they are quantitatively different. That is, in contrast to the equivalence results of Helpman (1981) and Lucas (1982), in this model the exchange rate system matters for real allocations. To make comparisons among these different exchange rate systems, the variability of real incomes and interest rates are examined across regimes. Variability orderings depend, in general, on the difference in interest elasticities of the demand for fiat money in the two countries and on the type of disturbance driving the business cycle. However, the flexible exchange rate regime generates the smallest variance in home-country income and interest rates in response to monetary shocks in the foreign country. The effect an exchange rate regime has on the variance-covariance properties of prices and aggregate quantities depends on two factors. First, the exchange rate system influences the substitutability among assets. For example, under the flexible exchange rate regime, fiat monies in the two countries are not substitutable; but with the monetary policy peg, fiat monies are essentially perfect substitutes. Second, the pattern of domestic monetary injections across states of the world depends on the exchange rate regime. Since anticipated money growth is nonneutral, this then has a bearing on fluctuations.

An important insight that comes from the explicit treatment of financial intermediation is that the features of the environment determining financial structure also determine the nature of business cycle phenomena. The model therefore defines a mapping from financial structure to business cycle phenomena, and this mapping changes with the exchange rate regime.

The paper is organized as follows. In Section 2 the model is constructed, and an equilibrium is characterized in Section 3. In Section 4, an equilibrium without fluctuations is examined to analyze the model's long-run properties. Section 5 discusses the characteristics of equilibrium fluctuations under three alternative exchange rate regimes, and Section 6 compares variability across these regimes. Section 7 presents conclusions.

2. The model

The model used is a two-country overlapping generations model with endogenous financial intermediation.[2] A closed-economy model with similar features is constructed by Williamson (1987), and a static model of financial intermediation with some of the same elements appears in Williamson (1986).

In each period a continuum of agents, distributed over the unit interval, is born. Each agent lives for two periods. Agents reside in two countries, where η is the measure of agents in the home country and $(1-\eta)$ is the measure of agents residing in the foreign country. Agents are either lenders or entrepreneurs, with $\eta\gamma$ denoting the measure of agents in the home country who are lenders and $(1-\eta)\gamma^*$ the measure of foreign lenders. Lenders differ from each other according to the value of a transactions cost parameter, α. In the home (foreign) country, lenders are distributed over R_+ by the continuously differentiable probability distribution function $F(\alpha)[F^*(\alpha)]$. The associated probability density functions are $f(\alpha)$ and $f^*(\alpha)$. Similarly, each entrepreneur is associated with a monitoring cost, β (which, as will be seen, is quite different from the α associated with a lender), and entrepreneurs in the home (foreign) country are distributed over R_+ by the continuously differentiable probability distribution function $G(\beta)[G^*(\beta)]$. The associated density functions are $g(\beta)$ and $g^*(\beta)$. Thus, for example, $(1-\eta)(1-\gamma^*)G^*(\beta')$ is the number of agents in a generation who live in the foreign country, who are entrepreneurs, and who have $\beta \leq \beta'$.

At $t = 1$, old agents are collectively endowed with M_1 units of domestic fiat money and M_1^* units of foreign fiat money. Fiat money is an unbacked, intrinsically useless asset which can be issued only by a government. Neither government can issue the other country's currency.

Each lender born at time t receives an endowment of one unit of the time t consumption good. Lenders consume only in their second period of life, and therefore save their entire endowment. At time t, consumption goods are consumed or used as inputs to the intertemporal production technology owned by entrepreneurs.

Lenders save either by acquiring fiat money in the first period of life or by lending to some other agent. (In equilibrium this other agent will be a <u>financial intermediary</u>.) If an agent is a lender, she must expend α units of <u>effort</u> in lending to another agent. The lender-specific transactions cost α can be interpreted as the cost of checking credit risk, the time spent in writing contracts and collecting payments from borrowers, trips to the bank, and so forth.[3] If a lender holds fiat money, no transactions costs are incurred, since fiat money cannot be counterfeited and is costlessly distinguishable as a government liability. A lender born at time t maximizes $E_t(c_{t+1}-\ell_t-\ell_{t+1})$, where E_t is the expectations operator conditioned on time t information, c_{t+1} is consumption at t + 1, and ℓ_t is effort expended at time t. Each lender's endowment of effort is unbounded.

If an agent is an entrepreneur born at time t, she has access to an investment project which produces $\tilde{w}$ units of the time t + 1 consumption good if funded with K units of the consumption good at time t, and which produces zero units if not funded. Here, K > 1 and $\tilde{w}$ is a random variable distributed according to the probability density function $h(\cdot;\theta_t)$, which is positive and continuously differentiable on $[0,\bar{w}]$, where $\bar{w} > 0$. Let $H(\cdot;\theta_t)$ denote the corresponding probability distribution function. The parameter θ_t orders distributions by first-order stochastic dominance. That is, $D_2H(w;\theta_t) < 0$, for $0 < w < \bar{w}$. Investment project returns are i.i.d. across entrepreneurs. The realized return on an investment project, denoted by w, is costlessly observable only to the individual entrepreneur, but any other agent may expend β units of effort to observe w. The value of β, which is specific to a particular entrepreneur, is publicly observable. Each entrepreneur receives endowments of zero units of effort and zero units of the consumption good in both periods of life, and each maximizes $E_t(c_{t+1})$.

The government of each country has access to lump-sum transfers and taxes on domestic agents, and these can be used as vehicles for injecting or retiring fiat money. For simplicity, it is assumed that all transfers and taxes are levied on old lenders. The home government may conduct asset exchanges of home-country fiat money for foreign fiat money, but the foreign government does not perform these asset exchanges. Domestic residents in each country are restricted by their respective governments from holding the other country's currency across periods.[4] Note that legal restrictions and lenders' transactions costs are jointly sufficient to assure exchange rate determinacy.

Portfolio restrictions imposed by the governments do not constrain the home government's ability to conduct open market operations in foreign exchange. For example, an open market sale of foreign fiat money can be carried out if the home government sells foreign currency from its portfolio in exchange for goods in the foreign country, and then sells those goods for fiat money in the home country. At time 1 the home government holds an initial stock of zero units of the foreign country's fiat money.

In what follows, the behavior of the foreign government is taken as exogenous, but the home government's behavior is endogenously determined through the choice, at $t = 1$, of the exchange rate regime. Under a flexible exchange rate system, the home government is noninterventionist, in that the outstanding stock of domestic fiat money is fixed for all t; no open market operations are conducted, and taxes and transfers are zero for all t. With a fixed exchange rate system, the behavior of the home government is subject to an exchange rate peg in addition to its budget constraint. Two methods of exchange rate pegging will be considered here. The first method fixes domestic monetary policy; no asset exchanges are conducted, and the exchange rate is pegged through a program of government deficits and surpluses financed by printing or retiring fiat money. The second method holds fiscal policy constant and pegs the exchange rate through asset exchanges in the foreign exchange market; the home government's deficit is fixed at zero.

2.1. Financial intermediation

In this environment with costly state verification [as in Townsend 1979)], a contract between a lender and an entrepreneur must provide for the monitoring of the entrepreneur for some realizations of the project return, due to a moral hazard problem. That is, if an entrepreneur's project is funded and the contract does not stipulate that monitoring will occur under some contingencies, then the entrepreneur will always declare that $w = 0$ and consume w. Optimally, contracts will serve to minimize the expected costs of monitoring while giving entrepreneurs the incentive to truthfully report returns. When attention is restricted to pure strategy contracts with nonstochastic monitoring, arguments similar to those of Williamson (1986,1987) can be used to show that an optimal arrangement is for all lending to be done by large (i.e., infinite-sized) intermediaries which borrow from many lenders and lend to many entrepreneurs.

Each intermediary is a single lender. Since intermediaries diversify by lending to a large number of entrepreneurs, contracts with depositors can specify a noncontingent payment of r_t per unit deposited, where r_t is the market expected return faced by depositors. Diversification thus eliminates delegated monitoring costs [as in Diamond (1984) and Williamson (1986)], since depositors need never monitor the intermediary. With free entry into intermediation, each intermediary earns zero profits (i.e., consumption by the intermediary just compensates for effort in monitoring), and intermediary agents will be those lenders with a transactions cost of zero. That is, if any lender with a positive transactions cost acts as an intermediary and offers contracts to entrepreneurs that earn nonnegative profits, a lender with a lower transactions cost could enter and offer these entrepreneurs contracts that they prefer and that earn positive profits.

A financial intermediary fully funds the investment projects of each of its borrowers and [as in Williamson (1986,1987)], it is <u>optimal</u> for the intermediary to write a <u>debt contract</u> with each of these entrepreneurs. That is, for a loan made in period t, the payment from an entrepreneur (who is indexed by β) to the intermediary at time $t + 1$ is x if $w \geq x$, and w if $w \leq x$, where x satisfies

$$\max_{x} \int_{x}^{\bar{w}} (w-x)h(w;\theta_t)dw \tag{2.1}$$

subject to

$$\int_{0}^{x} (w-\beta)h(w;\theta_t)dw + x\left[1-H(x;\theta_t)\right] = Kr_t. \tag{2.2}$$

Here, x maximizes the expected utility of the entrepreneur while giving the intermediary an expected return on the contract, net of monitoring costs and before compensating depositors, of Kr_t. Note that x can be interpreted as an interest payment, the state when $w < x$ as bankruptcy, and β as a cost of bankruptcy.

The left-hand side of equation (2.2) can be rewritten, via integration by parts, as

$$\Pi(x,\beta,\theta_t) = x - \int_0^x H(\mu;\theta_t)d\mu - \beta H(x;\theta_t). \tag{2.3}$$

Assume that $\Pi(\cdot,\cdot,\cdot)$ is strictly concave in its first argument. Then there is a unique $x_t^* \in [0,\bar{w}]$ such that $x_t^* = \arg\max_x \Pi(x,\beta,\theta_t)$. Let $\Pi^*(\beta,\theta_t) = \Pi(x_t^*,\beta,\theta_t)$ denote the <u>maximum</u> expected return an intermediary can earn on a loan to an entrepreneur with project monitoring cost β. From (2.3), and with an application of the envelope theorem, it follows up that $D_1\Pi^* < 0$. Now, an intermediary demands a return of r_tK on a loan to an entrepreneur. Thus, no entrepreneur with a monitoring cost greater than β_t' will be given a loan, where β_t' is implicitly determined by $\Pi^*(\beta_t',\theta_t) = r_tK$, since for this set of agents the expected return on a loan would fall below the market expected return. An entrepreneur with $\beta \le \beta_t'$ receives a loan with a gross interest payment of x, determined by (2.2). Consequently, there is a sense in which credit rationing occurs in equilibrium [as discussed at greater length in Williamson (1986)]. In what follows, the entrepreneur with monitoring cost β_t' and an associated interest payment x_t' will be called the <u>marginal borrower</u>.

3. Equilibrium

Goods and assets can be freely traded on international markets. Therefore, letting $p_t(p_t^*)$ denote the price of home-country (foreign) fiat money in terms of the consumption good [that is, the reciprocal of the domestic (foreign) price level], the law of one price must hold:

$$(1/p_t) = e_t(1/p_t^*) \tag{3.1}$$

where e_t is the domestic currency price of foreign exchange.

Suppose an agent is a lender with transactions cost α. Then if $r_t - \alpha \ge E_tp_{t+1}/p_t$, this agent exchanges her single unit of the consumption good for an intermediary deposit; otherwise, she holds fiat money. Thus, the agent who is indifferent between holding deposits and domestic fiat money has $\alpha = r_t - E_t p_{t+1}/p_t$. An equilibrium condition for the home-country market for fiat money is then

$$\eta\gamma[1-F(r_t-E_t p_{t+1}/p_t)] = p_t M_t. \tag{3.2}$$

Here, M_t is the stock of home-country fiat money at time t. Similarly, in the foreign country,

$$(1-\eta)\gamma^*[1-F^*(r_t-E_t p^*_{t+1}/p^*_t)] = p^*_t M^*_t \tag{3.3}$$

where M^*_t represents the foreign money stock <u>excluding</u> the stock of foreign currency reserves held by the domestic government.

Recall that the marginal borrower in the credit market has monitoring cost β'_t, which is determined by the condition $\Pi^*(\beta'_t,\theta_t) = \Pi(x'_t,\beta'_t,\theta_t) = r_t K$, where $x'_t = \arg\max_{x_t} \Pi(x_t,\beta'_t,\theta_t)$. Thus, from (2.3), the pair (β'_t,x'_t) is implicitly determined by the following two conditions:

$$x'_t - \int_0^{x'_t} H(u;\theta_t)du - \beta'_t H(x'_t;\theta_t) = Kr_t \tag{3.4}$$

and

$$1 - H(x'_t;\theta_t) - \beta'_t h(x'_t;\theta_t) = 0. \tag{3.5}$$

The equilibrium condition for the world credit market is then

$$\eta\gamma F(r_t-E_t p_{t+1}/p_t) + (1-\eta)\gamma^* F^*(r_t-E_t p^*_{t+1}/p^*_t)$$
$$= \eta(1-\gamma)KG(\beta'_t) + (1-\eta)(1-\gamma^*)KG^*(\beta'_t) \tag{3.6}$$

where the left-hand side of (3.6) is credit supply and the right-hand side is (in a sense) credit demand.

To close the model, a specification of the domestic and foreign governments' budget constraints is required. Since fiat money is the only liability of the home government, changes in its stock must be reflected either in transfer payments to domestic residents, T_t, or in changes in the domestic government's stock of foreign exchange, J_t. The home government's budget constraint can then be written as

$$p_t(z_t-1)M_{t-1} = T_t + p_t^*(J_t-J_{t-1}) \tag{3.7}$$

where z_t is defined as the period t <u>gross</u> growth rate in the domestic fiat money supply; that is,

$$M_t = z_t M_{t-1}. \tag{3.8}$$

Similarly, the foreign government's budget constraint is

$$p_t^*(z_t^*-1)(M_{t-1}^*+J_{t-1}) = T_t^*. \tag{3.9}$$

In (3.9), T_t^* denotes transfer payments to foreign residents, and z_t^* is the gross growth rate in the stock of foreign currency held by foreign residents and the home government; that is,

$$M_t^* + J_t = z_t^*(M_{t-1}^*+J_{t-1}). \tag{3.10}$$

Given a stochastic process $\{\theta_t,z_t,z_t^*\}$, equations (3.1)-(3.10) determine an equilibrium solution for $\{p_t,p_t^*,e_t,\beta_t',x_t',r_t\}$. The nature of the stochastic process $\{\theta_t,z_t,z_t^*\}$ depends on the exchange rate regime adopted by the home government. Also, which variables are treated as exogenous in the government budget constraints, (3.7) and (3.9), depends on the institutional arrangement considered. Given the above equilibrium solution, other variables of interest, such as incomes in each country, can also be determined in a straightforward manner.

4. Equilibrium without fluctuations

The long-run properties of the model will now be examined in a version of the model in which preferences, technology, the population, and all exogenous variables are constant over time. There will then be no equilibrium fluctuations arising from shocks to fundamentals. To proceed, let $\theta_t = \theta$, $z_t = z$, and $z_t^* = z^*$ for all t, where θ, z, and z^* are constants. Also, suppose $J_t = 0$ for all t, so that there are no open market exchanges. Attention will be restricted to stationary monetary equilibria, with p_t and $p_t^* > 0$, for all t; $x_t' = x'$, $\beta_t' = \beta'$, $r_t = r$; and $p_t M_t = q$ and $p_t^* M_t^* = q^*$, for all t. Here, x', β', r, q, and q^* are constants. This implies, given (3.8) and (3.10), that

$$p_{t+1}/p_t = 1/z \tag{4.1}$$

$$p_{t+1}^*/p_t^* = 1/z^* \tag{4.2}$$

for all t.

Next, substituting (4.1) and (4.2) into (3.2)-(3.6) yields

$$\eta\gamma\left[1-F(r-1/z)\right] = p_1 M_1 \tag{4.3}$$

$$(1-\eta)\gamma^*\left[1-F^*(r-1/z^*)\right] = p_1^* M_1^* \tag{4.4}$$

$$x' - \int_0^{x'} H(u;\theta)du - \beta' H(x';\theta) = Kr \tag{4.5}$$

$$1 - H(x';\theta) - \beta' h(x';\theta) = 0 \tag{4.6}$$

$$\eta\gamma F(r-1/z)+(1-\eta)\gamma^* F^*(r-1/z^*) = \eta(1-\gamma)KG(\beta')+(1-\eta)(1-\gamma^*)KG^*(\beta'). \tag{4.7}$$

The system of equations (4.1)-(4.7) provides a solution for x', β', r, and the sequence $\{p_t, p_t^*\}$. Note that (4.3) and (4.4) determine p_1 and p_1^*, and (4.1) and (4.2) then determine the entire sequence of prices of fiat money. Equations (4.3) and (4.4) thus hold for t = 2, 3, 4, ..., substituting $p_t M_t$ for $p_1 M_1$ and $p_t^* M_t^*$ for $p_1^* M_1^*$. This solution then implies values for domestic and foreign per capita incomes, y and y^*, as defined by

$$y \equiv \mu(1-\gamma)G(\beta') + \gamma \tag{4.8}$$

and

$$y^* \equiv \mu(1-\gamma^*)G^*(\beta') + \gamma^* \tag{4.9}$$

where $\mu \equiv \int_0^{\bar{w}} wh(w;\theta)dw$ is the expected return on an investment project. In (4.8), the first term is the per capita output from last period's domestic investment, while the second term is the per capita endowment of domestic agents. The components of y^* in (4.9) are the corresponding quantities for the foreign country.

Now, consider the equilibrium effects of a one-time increase in θ. The increase has the effect of improving investment opportunities, in that there is a first-order stochastic dominance shift in the distribution of project returns. (Note that this distribution is common to entrepreneurs' projects in both countries.) From (4.3)-(4.9), standard comparative statics gives

$$\frac{dr}{d\theta} = \frac{\left[\eta(1-\gamma)Kg+(1-\eta)(1-\gamma^*)Kg^*\right]\delta}{\Omega} > 0$$

$$\frac{d\beta'}{d\theta} = \frac{\left[\eta\gamma f+(1-\eta)\gamma^* f^*\right]\delta}{\Omega} > 0$$

$$\frac{dy}{d\theta} = (1-\gamma)\mu g(\beta')\frac{d\beta'}{d\theta} - (1-\gamma)G(\beta')\int_0^{\bar{w}} D_2H(w;\theta)dw > 0$$

$$\frac{dy^*}{d\theta} = (1-\gamma^*)\mu g^*(\beta')\frac{d\beta'}{d\theta} - (1-\gamma^*)G^*(\beta')\int_0^{\bar{w}} D_2H(w;\theta)dw > 0$$

where

$$\delta \equiv -\int_0^{x'} D_2H(u;\theta)du - \beta' D_2H(x';\theta) > 0$$

$$\Omega \equiv H\left[\eta\gamma f+(1-\eta)\gamma^* f^*\right] + K^2\left[\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*\right] > 0$$

$$f \equiv f(r-1),\ f^* \equiv f^*(r-1),\ g \equiv g(\beta'),\ g^* \equiv g^*(\beta'),\ H \equiv H(x';\theta).$$

Here, an increase in θ implies a decrease, for any loan interest payment x, in the probability of default, $H(x;\theta)$, and a corresponding fall in expected monitoring costs for each entrepreneur. As a result, the size of the pool of creditworthy entrepreneurs increases (β' rises); that is, the demand for loans rises. The world interest rate r then increases to clear the credit market. Since the expected return on each investment project is higher, and because more investment projects are funded, per capita output in each country increases.

Next, consider the impact of an increase in the foreign country's rate of monetary expansion z^* at each date t. The results of this experiment are

$$-\frac{1}{z^{*2}} < \frac{dr}{dz^*} < 0, \; \frac{d\beta'}{dz^*} > 0, \; \frac{dy}{dz^*} > 0, \text{ and } \frac{dy^*}{dz^*} > 0.$$

Since an increase in z^* reduces the rate of return on foreign fiat money, foreign residents substitute from fiat money to intermediated capital. This augments the worldwide supply of loanable funds and drives down the world real interest rate r. At the new, lower world interest rate, more entrepreneurs in both countries are eligible to receive loans since now there is less risk of bankruptcy. Income in both countries therefore increases. As a result, a long-run positive correlation between output and inflation--that is, a long-run Phillips relationship--will be observed. This can be contrasted to the properties of cash-in-advance models [such as Greenwood and Huffman (1987)] or overlapping generations models [similar to Lucas (1972)], with preferences defined over leisure and consumption. In these models, if money transfers are lump sum [as they are not in Lucas (1972)], then anticipated monetary expansions decrease labor supply and reduce output. The effects of such monetary expansions differ in the current model because of the effect of the credit allocation mechanism, which provides a direct link from credit to investment and output.

The above analysis of a deterministic steady state is intended to highlight operating characteristics of the model which will come into play in the following sections, where the model is subjected to stochastic technological and monetary disturbances. It is straightforward to perform some other simple experiments in a deterministic steady state. For example, in Greenwood and Williamson (1988), the equilibrium effects of one-time shifts in the distribution functions of transactions and monitoring costs are studied. There, it is shown that the model yields predictions consistent with some stylized facts of economic growth and financial development.

5. Equilibrium with aggregate fluctuations

In this section, aggregate fluctuations are studied which are caused by real disturbances affecting technology in both countries and by monetary disturbances in the foreign country. These fluctuations are examined under three alternative policy regimes for the home country: (1) a flexible exchange rate regime, where the home government has a deficit of zero in each period and conducts no asset exchanges; (2) a fiscal policy peg, where the exchange rate is fixed and monetary policy is held constant; and (3) a monetary policy peg, where the exchange rate is fixed and fiscal policy is held constant.

The particular flexible exchange rate regime was chosen since it is noninterventionist, in that the home-country's stock of fiat money is fixed for all t. Note, however, that this takes the framework of legal restrictions as given. The pegged exchange rate systems represent two extremes in a continuum of policy programs for pegging exchange rates--programs containing different degrees of fiscal and monetary intervention. These policy regimes may not correspond to alternatives that are usually considered. In particular, flexible exchange rate regimes are more typically viewed as systems under which domestic policy is unconstrained by exchange rate considerations. The laissez-faire flexible exchange rate regime considered here abstracts from the strategic issues that arise elsewhere in the study of flexible exchange rate systems. Note that the fiscal and monetary policy pegs do not correspond to sterilized and nonsterilized interventions, since there is no interest-bearing government debt in the model. Also, while the monetary policy peg is similar to Helpman's (1981) "cooperative peg," his "one-sided peg" involves open market operations in private debt, and thus is quite different from the fiscal policy peg.

Stochastic technological disturbances and foreign monetary shocks are introduced as follows. Let s_t denote the state of the world at time t, with $s_t = 1, 2$, where s_t follows a Markov process with

$$\Pr[s_t=1|s_{t-1}=i] = q_i, \text{ for } i = 1, 2.$$

Here, $0 < q_i < 1$, for $i = 1, 2$, and $q_1 \geq q_2$, so that s_t is nonnegatively serially correlated. If $s_t = i$, then $z_t^* = z_i^*$ and $\theta_t = \theta_i$, for $i = 1, 2$.[5] The unconditional probabilities are then

$$\Pr[s_t=1] = \frac{q_2}{1 - q_1 + q_2} \text{ and } \Pr[s_t=2] = \frac{1 - q_1}{1 - q_1 + q_2}.$$

In what follows, attention will be restricted to stationary monetary equilibria, where interest rates and quantities depend only on s_t, $p_t > 0$, and $p_t^* > 0$, for all t.

5.1. Flexible exchange rate regime

Under the flexible exchange rate regime, the home-country supply of fiat money remains fixed; that is, $z_t = 1$ for all t. Also, $T_t = 0$ and $J_t = 0$ for all t. Let π_t represent the realized <u>gross</u> return on domestic fiat money between periods t and t + 1; that is, $\pi_t \equiv p_{t+1}/p_t$. This realized rate of return can assume one of four possible values, denoted by π_{ij}, for $i, j = 1, 2$, where π_{ij} is the realized gross return on foreign currency if $s_{t+1} = i$ and $s_t = j$. The gross rates of return on foreign currency, π_{ij}^*, for $i, j = 1, 2$, are defined similarly. From (3.2), (3.3), (3.8), and (3.9), and setting $z_1^* = 1$ as is done in the following analysis, one obtains

$$\pi_{11} = \pi_{22} = \pi^*_{11} = 1 \tag{5.1}$$

$$\pi^*_{22} = 1/z^*_2 \tag{5.2}$$

$$\pi^*_{21} = 1/\pi^*_{12}z^*_2 \tag{5.3}$$

$$\pi_{21} = 1/\pi_{12}. \tag{5.4}$$

The expected returns on domestic and foreign currencies if $s_t = i$, denoted by π^e_i and π^{*e}_i, are then given by

$$\pi^e_i = q_i\pi_{1i} + (1-q_i)\pi_{2i} \text{ and } \pi^{*e}_i = q_i\pi^*_{1i} + (1-q_i)\pi^*_{2i}, \text{ for } i = 1, 2. \tag{5.5}$$

For this regime, an equilibrium is determined analogously to (3.2)-(3.10) as follows, using (5.1)-(5.5):

$$1 - F\left(r_1-q_1-(1-q_1)/\pi_{12}\right) - \pi_{12}\left[1-F\left(r_2-q_2\pi_{12}-(1-q_2)\right)\right] = 0 \tag{5.6}$$

$$1 - F^*\left(r_1-q_1-(1-q_1)/\pi^*_{12}z^*_2\right) - \pi^*_{12}\left[1-F^*\left(r_2-q_2\pi^*_{12}-(1-q_2)/z^*_2\right)\right] = 0 \tag{5.7}$$

$$x'_i - \int_0^{x'_i} H(u;\theta_i)du - \beta'_iH(x'_i;\theta_i) = Kr_i, \text{ for } i = 1, 2 \tag{5.8}$$

$$1 - H(x'_i;\theta_i) - \beta'_ih(x'_i;\theta_i) = 0, \text{ for } i = 1, 2 \tag{5.9}$$

$$\begin{aligned} &\eta\gamma F\left(r_1-q_1-(1-q_1)/\pi_{12}\right) + (1-\eta)\gamma^*F^*\left(r_1-q_1-(1-q_1)/\pi^*_{12}z^*_2\right) \\ &\quad = \eta(1-\gamma)KG(\beta'_1) + (1-\eta)(1-\gamma^*)KG^*(\beta'_1) \end{aligned} \tag{5.10}$$

$$\begin{aligned} &\eta\gamma F(r_2-q_2\pi_{12}-1+q_2) + (1-\eta)\gamma^*F^*\left(r_2-q_2\pi^*_{12}-(1-q_2)/z^*_2\right) \\ &\quad = \eta(1-\gamma)KG(\beta'_2) + (1-\eta)(1-\gamma^*)KG(\beta'_2). \end{aligned} \tag{5.11}$$

Here, subscripts on variables denote states so that, for example, r_i is the deposit interest rate when $s_t = i$. Equations (5.6)-(5.11), in conjunction with (5.1)-(5.5), solve for r_i, x'_i, β'_i, π^e_i, π^{*e}_i, for $i = 1, 2$, and for π_{ij}, π^*_{ij}, for $i, j = 1, 2$.

Given the above solutions, other variables of interest can be computed as follows. First, as in (4.8) and (4.9), per capita income in each country are given by

$$y_i = \mu_i(1-\gamma)G(\beta_i') + \gamma, \text{ for } i = 1, 2 \tag{5.12}$$

$$y_i^* = \mu_i(1-\gamma^*)G^*(\beta_i') + \gamma^*, \text{ for } i = 1, 2 \tag{5.13}$$

where $\mu_i \equiv \int_0^{\bar{w}} wh(w;\theta_i)dw$. Here, $y_t = y_i$ and $y_t^* = y_i^*$ if $s_{t-1} = i$. Second, net borrowing by the home country is

$$b_1 = \eta(1-\gamma)KG(\beta_1') - \eta\gamma F\big(r_1-q_1-(1-q_1)/\pi_{12}\big) \tag{5.14}$$

$$b_2 = \eta(1-\gamma)KG(\beta_2') - \eta\gamma F(r_2-q_2\pi_{12}-1+q_2). \tag{5.15}$$

Thus, the capital account surplus in the home country, denoted by $k_{ij} \equiv b_i - b_j$ if $s_t = i$ and $s_{t-1} = j$, is

$$k_{11} = k_{22} = 0 \tag{5.16}$$

$$k_{12} = b_1 - b_2 = -k_{21}. \tag{5.17}$$

Finally, let ε_t denote the gross rate of depreciation in the exchange rate which occurs between periods t and t + 1, so that $\varepsilon_t = e_{t+1}/e_t$. As for π_t and π_t^*, ε_t can assume one of four values: ε_{ij}, for i, j = 1, 2. From (3.1) and (5.1)-(5.4), it follows that

$$\varepsilon_{11} = 1 \tag{5.18}$$

$$\varepsilon_{12} = \pi_{12}^*/\pi_{12} \tag{5.19}$$

$$\varepsilon_{21} = \pi_{12}/\pi_{12}^* z_2^* \tag{5.20}$$

$$\varepsilon_{22} = 1/z_2^*. \tag{5.21}$$

To analyze fluctuations, attention is confined to small perturbations to underlying state variables. The following comparative dynamics experiments involve differentiating with respect to θ_i and z_i^*, for i = 1, 2, around the deterministic equilibrium in which the points in the state space are $(\theta_1,z_1^*) = (\theta_2,z_2^*) = (\theta,1)$. This benchmark equilibrium is the stationary fixed money supply equilibrium with no technology shocks.

The objective of conducting these experiments is to uncover the variance-covariance structure of the endogenous variables of interest in the model, and to then compare this structure across exchange rate regimes. In equilibrium, most variables follow a two-state Markov process, as do the underlying shocks. Variances and covariances for these variables can then be computed in a straightforward manner. For example, if $\{a_t\}$ and $\{b_t\}$ are two stochastic processes, where $a_t = a_i$ and $b_t = b_i$ if $s_t = i$, then their contemporaneous unconditional covariance is

$$\mathrm{cov}(a_t, b_t) = \frac{(1-q_1)q_2}{(1-q_1+q_2)^2}(a_1-a_2)(b_1-b_2). \tag{5.22}$$

To find the covariance for a small perturbation to the benchmark equilibrium, a second-order Taylor expansion of (5.22) gives

$$\mathrm{cov}(a_t, b_t) \approx \frac{(1-q_1)q_2}{2(1-q_1+q_2)^2}\left[\frac{da_1}{d\omega} - \frac{da_2}{d\omega}\right]\left[\frac{db_1}{d\omega} - \frac{db_2}{d\omega}\right] \tag{5.23}$$

where $\omega = \theta_i$, z_i^*, for $i = 1, 2$. In computing covariances when a_t or b_t depend on s_{t+1} and s_t (as is the case for π_t, π_t^*, ε_t, and k_t), the formulae are in general more complicated than (5.22) and (5.23). However, if $a_t = \pi_t$, π_t^*, ε_t or k_t, with $a_t^e \equiv E_t a_t$, then direct computation gives

$$\mathrm{cov}(a_t, y_{t+1}) = \mathrm{cov}(a_t^e, y_{t+1}) \tag{5.24}$$

and (5.22) and (5.23) can then be used, given this particular timing of variables.

With this in mind, the equilibrium effects of a differential change in θ_2 are examined. This examination yields information on the variance-covariance structure under disturbances to the investment technology. The results are summarized as follows:

$$\frac{d\beta_1'}{d\theta_2} - \frac{d\beta_2'}{d\theta_2} = - \frac{\delta[\eta\gamma f a^*(1-F)+(1-\eta)\gamma^* f^* a(1-F^*)]}{\nabla} < 0 \tag{5.25}$$

$$\frac{dr_1}{d\theta_2} - \frac{dr_2}{d\theta_2} = - \frac{\delta a a^* K[\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*]}{\nabla} < 0 \tag{5.26}$$

$$\frac{d\pi_{12}}{d\theta_2} = -(f/a)[\frac{dr_1}{d\theta_2} - \frac{dr_2}{d\theta_2}] > 0 \tag{5.27}$$

$$\frac{d\pi_{12}^*}{d\theta_2} = -(f^*/a^*)[\frac{dr_1}{d\theta_2} - \frac{dr_2}{d\theta_2}] > 0 \tag{5.28}$$

$$\frac{dy_1}{d\theta_2} - \frac{dy_2}{d\theta_2} = \mu(1-\gamma)g[\frac{d\beta_1'}{d\theta_2} - \frac{d\beta_2'}{d\theta_2}] - (1-\gamma)G(\beta')\frac{d\mu_2}{d\theta_2} < 0 \tag{5.29}$$

$$\frac{d\varepsilon_{12}}{d\theta_2} = - \frac{d\varepsilon_{21}}{d\theta_2} = [\frac{f}{a} - \frac{f^*}{a^*}][\frac{dr_1}{d\theta_2} - \frac{dr_2}{d\theta_2}] \lesseqgtr 0 \tag{5.30}$$

$$\frac{db_1}{d\theta_2} - \frac{db_2}{d\theta_2} = \frac{(1-\eta)\eta\delta(K\gamma^* f^*(1-F^*)\gamma f(1-F)}{\nabla} \times [-\frac{(1-\gamma)ag}{\gamma f(1-F)} + \frac{(1-\gamma^*)a^*g^*}{\gamma^* f^*(1-F^*)}] \gtrless 0. \tag{5.31}$$

In (5.25)-(5.31),

$$F \equiv F(r-1), \quad F^* \equiv F^*(r-1)$$

$$\delta \equiv - \int_0^{x'} D_2H(u;\theta)du - \beta' D_2H(x';\theta) > 0$$

$$\nabla \equiv H[\eta\gamma f a^*(1-F)+(1-\eta)\gamma^* f^* a(1-F^*)] + aa^*K^2[\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*] > 0$$

$$a \equiv (1-q_1+q_2)f + (1-F), \quad a^* \equiv (1-q_1+q_2)f^* + 1 - F^*.$$

The signs for covariances of interest are reported in Table 1. With the more favorable distribution of investment returns available in state 2, the world demand for credit is higher than in state 1. As a result, real interest rates at time t and income at t + 1 are higher if $s_t = 2$ than if $s_t = 1$ [compare (5.26) and (5.29)]. Therefore, from (5.23), in each country real interest rates and output (with a one-period lead) are positively correlated and outputs across countries are contemporaneously positively correlated, provided that shocks are positively serially correlated ($q_1 > q_2$).

From (5.1), (5.4), (5.5), (5.24), (5.27), and (5.29), it follows that the inflation rate in each country is countercyclical. The exchange rate and the capital account surplus may be either procyclical or countercyclical. For the exchange rate, the outcome turns on the sign of $d\varepsilon_{12}/d\theta_2$, which from (5.30) depends on $f/a - f^*/a^*$, which in turn can be rewritten as

$$f/a - f^*/a^* = \left[1-q_1+q_2+(1-F)/f\right]^{-1} - \left[1-q_1+q_2+(1-F^*)/f^*\right]^{-1}.$$

An important term in the above expression is $f/(1-F)$, which is a <u>hazard rate</u>. In the model, it can be interpreted as the aggregate interest elasticity of demand for fiat money in the home country. Note that, if α' is the transactions cost faced by the lender in the home country who is indifferent between holding fiat money and holding intermediary deposits, then $1 - F(\alpha')$ is the fraction of home country lenders who hold fiat money. If $F(\cdot)$ and $F^*(\cdot)$ are uniform distributions (such that positive fractions of agents hold fiat money and deposits in each country in equilibrium), then the country in which more savings is intermediated and less currency is held in a steady state benchmark equilibrium has the higher money demand elasticity.

Given (5.23), (5.24), (5.29), and (5.30), exchange rate appreciations will be procyclical (countercyclical) if money demand is more (less) interest elastic in the home country than in the foreign country. That is, since the investment shock does not directly impinge on either country's market for fiat money, its effect on the exchange rate is limited to its differential impact on these two markets via its effect on the common world real interest rate. The country with the highest interest sensitivity of demand for fiat money will experience the strongest countercyclical movement in inflation. Consequently, appreciations (depreciations) in that country's exchange rate will be procyclical (countercyclical). The correlation between exchange rate depreciations and the capital account surplus is ambiguous, even given the sign of $f^*(1-F) - f(1-F^*)$. Movements in the capital account surplus depend upon the characteristics of both savers and entrepreneurs [see equation (5.31)].

Next, for the case of monetary disturbances, consider the effects of a small perturbation in z_2^* around the point in the state space where $(\theta_1, z_1^*) = (\theta_2, z_2^*) = (\theta, 1)$. The results of this exercise are summarized in Table 1, which obtain from the following expressions:

$$\frac{d\beta_1'}{dz_2^*} - \frac{d\beta_2'}{dz_2^*} = -\frac{(1-\eta)\gamma^* f^* Ka(q_1-q_2)(1-F^*)}{\nabla} < 0 \tag{5.32}$$

$$\frac{dr_1}{dz_2^*} - \frac{dr_2}{dz_2^*} = -\frac{H}{K}\left[\frac{d\beta_1'}{dz_2^*} - \frac{d\beta_2'}{dz_2^*}\right] > 0 \tag{5.33}$$

$$\frac{d\pi_{12}}{dz_2^*} = \frac{fH}{Ka}\left[\frac{d\beta_1'}{dz_2^*} - \frac{d\beta_2'}{dz_2^*}\right] < 0 \tag{5.34}$$

$$\frac{d\pi_{12}^*}{dz_2^*} = \frac{(q_1-q_2)f^*\{\eta\gamma f a^*(1-F)H + aa^*K^2[\eta(1-\gamma)g + (1-\eta)(1-\gamma^*)g^*]\}}{a^*\nabla} > 0 \tag{5.35}$$

$$\frac{d\varepsilon_{12}}{dz_2^*} = \frac{d\pi_{12}^*}{dz_2^*} - \frac{d\pi_{12}}{dz_2^*} > 0 \tag{5.36}$$

$$\frac{d\varepsilon_{21}}{dz_2^*} = \frac{d\pi_{12}}{dz_2^*} - \frac{d\pi_{12}^*}{dz_2^*} - 1 < 0 \tag{5.37}$$

$$\frac{db_1}{dz_2^*} - \frac{db_2}{dz_2^*} = \eta[(1-\gamma)Kg + \gamma fH(1-F)/Ka]\left[\frac{d\beta_1'}{dz_2^*} - \frac{d\beta_2'}{dz_2^*}\right] < 0 \tag{5.38}$$

$$\frac{dy_1}{dz_2^*} - \frac{dy_2}{dz_2^*} = \mu(1-\gamma)g\left[\frac{d\beta_1'}{dz_2^*} - \frac{d\beta_2'}{dz_2^*}\right] < 0 \tag{5.39}$$

$$\frac{dy_1^*}{dz_2^*} - \frac{dy_2^*}{dz_2^*} = \mu(1-\gamma)g\left[\frac{d\beta_1'}{dz_2^*} - \frac{d\beta_2'}{dz_2^*}\right] < 0. \tag{5.40}$$

From (5.32), (5.39), and (5.40), output in each country is positively correlated with money growth in the foreign country. This expansionary impact of money on output is due to the credit allocation mechanism discussed in Section 4. Note that if shocks to money growth in the foreign country are not serially correlated ($q_1=q_2$), then there are no cyclical effects from these monetary disturbances. Current money growth has cyclical effects only to the extent that it is informative about future money growth and the real return on fiat money.

Next, from (5.1)-(5.4), (5.23), (5.24), (5.33)-(5.35), (5.39) and (5.40), the world real interest rate moves countercyclically, while inflation rates in both countries are procyclical. The domestic supply of fiat money remains constant, implying that the domestic inflation rate is procyclical because of the impact of foreign monetary disturbances on the domestic demand for money via the real interest rate. For example, suppose that $s_t = 2$. Then, the world real interest rate is low and each country's output (next period) is high. Thus, the domestic demand for fiat money will be high, and the domestic price level will be low. Domestic residents at time t expect inflation. This transpires since if $s_{t+1} = 2$, the price level will remain constant; but if $s_{t+1} = 1$, the domestic price level will rise as the real interest rate will have risen. The opposite holds if $s_t = 1$. Thus a high (low) level of output is associated <u>on average</u> with inflation (deflation).

Finally, (5.23), (5.24), and (5.36)-(5.40) imply that domestic (foreign) exchange rate <u>appreciations</u> and capital account deficits are procyclical (countercyclical) and positively correlated. Though inflation rates are procyclical in both countries, the impact of the foreign money disturbances on the domestic price level is indirect, coming through the credit market, and the procyclical foreign price movement is therefore stronger. Thus, appreciations (depreciations) in the home (foreign) country's exchange rate are positively correlated with output. When a monetary innovation occurs in the foreign country, this induces foreign savers to substitute from fiat money to intermediated assets, which tends to cause an outflow of capital from the foreign country. In the next period, income rises in the foreign country and there is an inflow of funds as the principal on international lending is repatriated. Thus, the foreign capital account surplus is positively correlated with output.

These predictions (in addition to the output effects noted above) are different from those obtained from Mundell-Fleming models, in which a monetary injection causes (in the country where it originates) the capital account surplus to move countercyclically. However, in some ways the model's credit allocation mechanism--linking credit, investment, and output--generates patterns of covariation in the data broadly reminiscent of the properties of static, closed-economy fixed-price models. That is, monetary (real) shocks produce business cycles where decreases (increases) in the real interest rate are associated with increases in output.[6]

5.2. Fixed exchange rate regime with fiscal policy peg

Under this exchange rate regime, the home government fixes the exchange rate via changes in the domestic supply of fiat money brought about through transfer payments to foreign residents. The exchange rate is pegged at some arbitrary level $\bar{e}$, where $e_t = \bar{e} > 0$ for all t. From the law of one price (3.1), this implies that $\pi_{ij} = \pi^*_{ij}$ for all i, j.

Setting $J_t = 0$ for all t, so that the home government holds no foreign exchange, from (3.2)-(3.8) the equilibrium conditions for this exchange rate regime are (5.8), (5.9), and

$$1 - F^*(r_1-q_1-(1-q_1)/\pi_{12}z_2^*) - \pi_{12}[1-F^*(r_2-q_2\pi_{12}-(1-q_2)/z_2^*)] = 0 \qquad (5.41)$$

$$\eta\gamma F(r_1-q_1-(1-q_1)/\pi_{12}z_2^*) + (1-\eta)\gamma^*F^*(r_1-q_1-(1-q_1)/\pi_{12}z_2^*)$$
$$= \eta(1-\gamma)KG(\beta_1') + (1-\eta)(1-\gamma^*)KG(\beta_1') \qquad (5.42)$$

$$\eta\gamma F(r_2-q_2\pi_{12}-(1-q_2)/z_2^*) + (1-\eta)\gamma^*F^*(r_2-q_2\pi_{12}-(1-q_2)/z_2^*)$$

$$= \eta(1-\gamma)KG(\beta_2') + (1-\eta)(1-\gamma^*)KG(\beta_2'). \tag{5.43}$$

Equations (5.8), (5.9), and (5.41)-(5.43) solve for x_i', β_i', r_i, for i = 1, 2, and π_{12}. To determine the pattern of domestic monetary injections and withdrawals supporting the fixed exchange rate, let z_{ij} denote the gross money growth rate in the home country when $s_t = i$ and $s_{t-1} = j$. The z_{ij} are then determined, given the solution to (5.8), (5.9), and (5.41)-(5.43) and again setting $z_1^* = 1$, by

$$z_{11} = 1 \qquad z_{21}z_{12} = z_2^* \qquad z_{22} = z_2^*$$

$$1 - F\left(r_1-q_1-(1-q_1)/\pi_{12}z_2^*\right) - \pi_{12}z_{12}\left[1-F\left(r_2-q_2\pi_{12}-(1-q_2)/z_2^*\right)\right] = 0. \tag{5.44}$$

Incomes in each country are again given by (5.12) and (5.13). Home-country borrowing is now

$$b_1 = \eta(1-\gamma)KG(\beta_1') - \eta\gamma F\left(r_1-q_1-(1-q_1)/\pi_{12}z_2^*\right) \tag{5.45}$$

$$b_2 = \eta(1-\gamma)KG(\beta_2') - \eta\gamma F\left(r_2-q_2\pi_{12}-(1-q_2)/z_2^*\right). \tag{5.46}$$

Following the same procedure used for the flexible exchange rate regime and using (5.8), (5.9), and (5.41)-(5.46), the signs of key covariances under technological disturbances are presented in Table 1. Algebraic expressions corresponding to (5.25)-(5.31) are provided in Greenwood and Williamson (1988). Note that fixing the exchange rate in this manner does not affect the qualitative features of the cycle relative to the flexible exchange rate regime. Again, the rate of inflation in each country is countercyclical, while the real interest rate is positively correlated with output (with a lead of one period). However, the sign of the covariance of the capital account with y_{t+1} might be different in this regime than with the flexible exchange rate system, under technological disturbances.

For monetary disturbances, the results are again summarized in Table 1, and algebraic expressions are in Greenwood and Williamson (1988). Note again that the qualitative comovements among incomes, real interest rates, and inflation are the same as under the flexible exchange regime, though the nature of the cycle under each regime is quantitatively different, as will be shown. Though the capital account may move differently across states in response to monetary and real shocks under the flexible exchange rate regime, this is not the case here. This occurs since under a fixed exchange rate system both countries experience common movements in the real interest rate and inflation. Consequently, all that matters for the effect on the capital account is the differential responses of savers and investors across countries to shifts in rates of return [see Greenwood and Williamson (1988)].

5.3. Fixed exchange rate regime with monetary policy peg

Under this regime, the domestic government fixes the exchange rate through open market operations in foreign exchange. (Thus, let $T_t=0$ for all t.) In contrast to what occurs with the fiscal policy peg, these asset exchanges do not affect the world supply of fiat money (valued in terms of either currency). The equilibrium behavior of the economy is examined here only for the case $z_2^* > 1$ (and $z_1^*=1$ as before), i.e., only the case of positive trend growth in foreign fiat money is considered. Given this, the gross growth rate of the world supply of fiat money approaches z_t^* in the limit as $t \to \infty$. As in Kareken and Wallace (1981), a version of Gresham's law holds, in that the fraction of domestic fiat money not backed by foreign fiat money tends to zero in the limit as $t \to \infty$. That is, in the limit, the trend growth rate in the home country's stock of foreign exchange is equal to the trend growth rate in the stock of foreign fiat money held in the foreign country.

As in the fiscal peg regime, $\pi_{ij} = \pi^*_{ij}$ for all i, j. From (3.2)-(3.8), the equilibrium conditions which solve for x_i', β_i', r_i, for i = 1, 2, and π_{12} are (5.8), (5.9), (5.42), (5.43), and

$$\begin{aligned}&\eta\gamma\left[1-F\left(r_1-q_1-(1-q_1)/\pi_{12}z_2^*\right)\right] - \eta\gamma\pi_{12}\left[1-F\left(r_2-q_2\pi_{12}-(1-q_2)/z_2^*\right)\right] \\ &\quad + (1-\eta)\gamma^*\left[1-F^*\left(r_1-q_1-(1-q_1)/\pi_{12}z_2^*\right)\right] \\ &\quad - (1-\eta)\gamma^*\pi_{12}\left[1-F^*\left(r_2-q_2\pi_{12}-(1-q_2)/z_2^*\right)\right] = 0. \qquad (5.47)\end{aligned}$$

Equation (5.47) is the market-clearing condition for fiat money. Incomes in each country and home-country borrowing are given by (5.12), (5.13), (5.45), and (5.46). Note that in this regime, the actions of the home government effectively make the portfolio restrictions on currency holdings nonbinding. The home government carries out the net transfers of foreign currency between domestic and foreign residents which would occur in the absence of legal restrictions, so that the segmentation of markets is eliminated. This regime might then more correctly be interpreted as the laissez-faire regime.

Using (5.8), (5.9), (5.42), (5.43), and (5.47), key covariances under technological and monetary disturbances can be determined [see Greenwood and Williamson (1988) for the algebraic expressions]. The signs of these covariances are in Table 1. The qualitative comovements among incomes, real interest rates, inflation, and the current account are identical under this and the fiscal peg regime, though there are quantitative differences.

Qualitatively, the results of this section are broadly consistent with conventional views concerning the transmission of business cycles between countries. That is, incomes, interest rates, and inflation rates tend to move together across countries over the cycle. These conventional views find empirical support in the work of Mitchell (1928), Morgenstern (1959), and Klein and Moore (1985), who show, using National Bureau of Economic Research business cycle dating techniques, that there exists a high degree of business cycle synchronization among major industrialized economies. Backus and Kehoe (1988) also show that output tends to be positively correlated across 11 highly-developed countries, and Camen (1987) finds a high degree of synchronization among national business cycles. The model constructed here shows, via explicit modeling of world financial integration, that inflation can be transmitted to a country even when it pursues a fixed money supply rule under a flexible exchange rate, whether the initial source of the inflation is a real or monetary shock. Consistent with these predictions, Klein and Moore (1985) find a high degree of comovement among inflation rates in seven industrialized countries, even following the abandonment of the Bretton Woods arrangement.

With regard to inflation/output correlations, the disappearance of Phillips relationships is now enshrined in undergraduate macroeconomics texts, such as Barro (1984). For the 1970's, a period usually characterized as being dominated by real macroeconomic disturbances, there is a negative correlation between detrended prices and detrended output in U.S. data (see Prescott 1983). The model studied here delivers positive inflation/output correlations under monetary disturbances and negative correlations with technological disturbances, for all exchange rate regimes examined.

6. Variability under alternative exchange rate regimes

Though business cycle phenomena are qualitatively similar across exchange rate regimes in the model, there are quantitative differences, and the purpose of this section is to study these differences. Here, a comparison is made of the variance of home country output, y_t, and of the interest rate, r_t, across the three exchange rate systems. Variances can be computed for small perturbations as in Section 5, by using (5.23) and (5.24). In what follows, σ_y^m will denote the standard deviation of income (in either country) and σ_r^m the standard deviation of the real interest rate under exchange rate system m, when the impulses are real disturbances. Here, m = a for the flexible exchange rate regime, m = b for the fiscal policy peg, and m = c for the monetary policy peg. Similarly, ρ_y^m and ρ_r^m are the standard deviations of income and the real interest rate, respectively, when the impulses are foreign money shocks.[7]

6.1. Real disturbances

Under small real disturbances, by using (5.25), and its analogues for the other two regimes [see Greenwood and Williamson (1988)], the following results are obtained for the standard deviation of output:

Flexible versus fiscal peg

$$\sigma_y^a - \sigma_y^b \propto \delta a^* K^2[\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*]\eta\gamma f(1-q_1+q_2) \times \frac{[f^*(1-F)-f(1-F^*)]}{\Sigma\nabla}.$$

Flexible versus monetary peg

$$\sigma_y^a - \sigma_y^c \propto -\delta K^2[\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*]\eta(1-\eta)\gamma\gamma^* \times \frac{(1-q_1+q_2)[f(1-F^*)-f^*(1-F)]^2}{\nabla\Psi}.$$

Fiscal peg versus monetary peg

$$\sigma_y^b - \sigma_y^c \propto \delta K^2[\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*][\eta\gamma f+(1-\eta)\gamma^* f^*](1-q_1+q_2) \times \frac{\eta\gamma[f(1-F^*)-f^*(1-F)]}{\Sigma\Psi}$$

with the same proportionality factor in each case. Here,

$$\Sigma \equiv (1-F^*)H[\eta\gamma+(1-\eta)\gamma^* f^*] + a^* K^2[\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*] > 0$$

$$\Psi \equiv H[\eta\gamma f+(1-\eta)\gamma^* f^*][\eta\gamma(1-F)+(1-\eta)\gamma^*(1-F)^*] + K^2[\eta\gamma a+(1-\eta)\gamma^* a^*][\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*] > 0.$$

Therefore,

$$\sigma_y^c > \sigma_y^a > \sigma_y^b, \text{ if } f^*(1-F) - f(1-F^*) > 0 \tag{6.1}$$

$$\sigma_y^b > \sigma_y^c > \sigma_y^a, \text{ if } f^*(1-F) - f(1-F^*) < 0 \tag{6.2}$$

and

$$\sigma_y^b = \sigma_y^c = \sigma_y^a, \text{ if } f^*(1-F) - f(1-F^*) = 0. \tag{6.3}$$

Using (5.26) and its analogues for the other two regimes, relative income and real interest rate standard deviations are related as follows:

$$\sigma_r^m - \sigma_r^n \propto - \frac{H}{K} (\sigma_y^m - \sigma_y^n) \tag{6.4}$$

for m, n = a, b, c. Therefore, the variability orderings for income in (6.1)-(6.3) are reversed for the real interest rate.

There are two features of the results for which some intuition is helpful. The first is the reversal of the variability ordering across regimes for income as opposed to the interest rate, and the second is the ordering itself. Though the results come from general equilibrium experiments, useful intuition is gained if a partial equilibrium model of the world credit market is considered, where the price in this market is the real interest rate and the quantity of credit is linked directly to output. Then, the real shock which occurs when $s_t = 2$ is essentially a shift in the credit demand curve. Thus, the equilibrium real interest rate increases more, and the quantity of credit and output increases less, as the supply of credit becomes less interest-elastic. Since the exchange rate regime affects only the supply side of the credit market, this then explains why variability orderings across regimes are reversed for output and the real interest rate, as in (6.4).

To understand the differences in the variability of income and interest rates under real disturbances across exchange rate regimes, one needs to understand how the interest elasticity of world credit supply is affected by the exchange rate system. In the model the underlying responses of asset demands to changes in expected rates of return are determined by endowments and preferences, and these responses therefore do not vary across exchange rate regimes. However, the exchange rate system affects the sensitivity to interest rate changes of rates of return on fiat money in the two countries. This is then reflected in differences in the aggregate elasticity of world credit supply in the different exchange rate regimes. For example, compare the flexible exchange rate regime with the monetary policy peg. Under the first exchange rate system, the two fiat monies are not substitutable and rates of return on fiat money are determined in each country's money market. However, with the monetary policy peg the two fiat monies are essentially perfect substitutes (because of the open market exchanges carried out by the home government), and the rate of return on fiat money is determined on a world money market. Thus, under a flexible exchange rate regime, the country with the highest interest elasticity of money demand experiences the largest increase in the rate of return on fiat money. This is because of a portfolio substitution effect. The interest elasticity of world credit supply is therefore lower, and output variability smaller, with the flexible exchange rate system than with the monetary policy peg.

Next, compare the fiscal policy peg with the monetary policy peg. With the fiscal policy peg, the home government equates rates of return on fiat monies by manipulating domestic money so that the home-country market for fiat money mimics the foreign money market. Thus, the rate of return on fiat money is essentially determined in the foreign money market. When the foreign country has the lowest (highest) interest elasticity of demand for fiat money, this dampens (amplifies) the upward movement in the rate of return on fiat money that occurs when the world real interest rate rises. Thus, the interest elasticity of world credit supply is larger (smaller) under the fiscal policy peg (versus the monetary policy peg) when the foreign country has the lowest (highest) interest elasticity of demand for fiat money. With a similar argument explaining the differences in the elasticity of world credit supply between the flexible exchange rate system and the fiscal policy peg, this then explains the variability orderings in (6.1)-(6.4).

6.2. Monetary disturbances

In line with the analysis of Section 5, the relative variabilities across regimes in income and the real interest rate are again examined; here, however, the impulses are foreign monetary shocks rather than real disturbances. In a similar manner to the real shock case, by using (5.32), (5.33), and similarly-derived results from the other two regimes, the following are obtained:

Flexible versus fiscal peg

$$\rho_y^a - \rho_y^b \propto -\left[(q_1-q_2)K(1-F^*)\eta\gamma f a^*/\nabla\Sigma\right]\left\{H\left[\eta\gamma f+(1-\eta)\gamma^* f^*\right](1-F) + aK^2\left[\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*\right]\right\}.$$

Flexible versus monetary peg

$$\rho_y^a - \rho_y^c \propto -\left[(q_1-q_2)K\eta\gamma/\nabla\Psi\right]\left\{H\left[\eta\gamma f+(1-\eta)\gamma^* f^*\right] \times f a^*(1-F)\left[\eta\gamma(1-F)+(1-\eta)\gamma^*(1-F^*)\right] + aK^2\left[\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*\right] \times \left[\eta\gamma f a^*(1-F)+(1-\eta)\gamma^* f(1-F)^2+(1-\eta)\gamma^* f^{*2}(1-q_1+q_2)(1-F)\right]\right\}.$$

Fiscal peg versus monetary peg

$$\rho_y^b - \rho_y^c \propto \left[(q_1-q_2)K^3/\Sigma\Psi\right]\left[\eta\gamma f+(1-\eta)\gamma^* f^*\right]\left[\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*\right] \times \eta\gamma(1-q_1+q_2)\left[f(1-F^*)-f^*(1-F)\right].$$

The relative income and real interest rate standard deviations are related in the following way:

$$\rho_r^m - \rho_r^n \propto \frac{H}{K}(\rho_y^m - \rho_y^n) \tag{6.5}$$

for m, n = a, b, c. Therefore, it follows that

$$\rho_j^c > \rho_j^b > \rho_j^a, \text{ if } f^*(1-F) - f(1-F^*) > 0 \tag{6.6}$$

$$\rho_j^b > \rho_j^c > \rho_j^a, \text{ if } f^*(1-F) - f(1-F^*) < 0 \tag{6.7}$$

and

$$\rho_j^b = \rho_j^c > \rho_j^a, \text{ if } f^*(1-F) - f(1-F^*) = 0 \tag{6.8}$$

for j = y, r.

The same partial equilibrium intuition as for the real shock case can be applied to explain these results. With monetary shocks the demand for credit is unaffected and the supply of credit function shifts. As a result, the variability orderings for income and the real interest rate will be identical across regimes [see (6.5)]. If a foreign monetary disturbance shifted the credit supply function by the same amount under each exchange rate regime, then the variability orderings for income would be the reverse of the orderings for the real disturbance case. However, from (6.1)-(6.8), this is not so. That is, the shift in the credit supply function caused by a foreign money disturbance is different under each of the three exchange rate regimes. In fact, it is the shift in the curve, and not its interest elasticity, which determines the variability orderings for the money shock case.

In comparing the flexible exchange rate regime to either of the fixed exchange rate systems, note that the domestic market for fiat money is insulated from the direct effects of foreign money shocks in the flexible regime, but not in the fixed regimes. Thus, less substitution from fiat money to intermediated credit is induced in the flexible regime relative to the fixed regimes; therefore, output in the flexible regime is less variable. The important difference between the fiscal and monetary peg regimes is that, in transition states, money growth in the home country differs from that in the foreign country under the fiscal peg, but does not differ under the monetary peg (asymptotically). The rates of money growth in transition states for the fiscal peg regime are given in (5.44). Note that in a transition from state 2 to state 1, money demand increases since the expected return on money rises. If the home country has a higher (lower) interest elasticity of demand for money than the foreign country, then to peg the exchange rate under the fiscal policy peg, it must increase (decrease) its (and therefore the world's) money supply. Thus in state 2, if money demand is more (less) interest-elastic in the home country than in the foreign country, then agents anticipate higher (lower) money growth in the fiscal peg regime than in the monetary peg regime. Since higher money growth is anticipated, more substitution is induced from money to intermediated credit, and hence output is more variable. This explains (6.5)-(6.8).

6.3. Remarks

Up to this point, welfare issues have not been addressed, since a proper treatment of those issues is a topic for another paper. However, note that neither the variance of income nor of the real interest rate is directly related to any appropriate welfare measure, given the preferences of agents in the model. In fact, since all agents are risk neutral, they are indifferent to mean-preserving spreads in the distribution of consumption. A reasonable conjecture is that the three exchange rate regimes cannot be Pareto-ranked, since if agents in a given generation face a higher real interest rate, all lenders are better off and all entrepreneurs are worse off.

The results of this section have a bearing on traditional debates about the insulating properties of different exchange rate systems. (See, for example, Friedman 1953.) In this traditional view, an exchange rate regime provides better insulation if the variance of some key variable, usually income, is lower under that regime than under an alternative one. (Here, keep in mind the above comments on the use of income variability as a welfare measure in the model.) If the focus is on the variability of income, the flexible exchange rate regime insulates best against foreign monetary disturbances [see (6.6)-(6.8)], but it may or may not provide the best insulation against real disturbances affecting both countries [see (6.1)-(6.3)]. However, if it were the goal of domestic policy to minimize output variance, and a flexible exchange rate regime were defined to be a system where domestic policy is unconstrained by exchange rate goals, then clearly the flexible exchange rate regime must dominate. Note, though, that this approach abstracts from strategic considerations.[8]

In other recent work comparing alternative exchange rate regimes, [e.g., Helpman (1981) and Lucas (1982)], the choice between a fixed and flexible exchange rate regime has no implications for real allocations in environments where money is neutral. Aschauer and Greenwood (1983) show that the equivalence result does not hold in a version of Helpman's model which includes a labor-leisure choice. This feature implies that anticipated changes in money growth are not neutral in their model, as is the case in the model studied here [see also Stockman (1985) and Greenwood and Huffman (1987)]. Note, however, that in Aschauer and Greenwood (1983), an increase in money growth and inflation acts as a tax on labor effort, and output <u>falls</u>; while in this model the same disturbance causes portfolio substitution into intermediated credit, and output <u>increases</u>.

Summary and Conclusions

In this paper, a two-country overlapping generations model with endogenous financial intermediation was constructed. This is a model with perfect capital mobility, where there is an explicit account of the manner in which institutions arise to carry out international borrowing and lending. Key features of the environment that give rise to the equilibrium financial structure are the transactions costs faced by lenders and the costs of monitoring borrowers. The existence of transactions costs implies that intermediary liabilities dominate fiat money in terms of expected rate of return, while diversified financial intermediaries which write debt contracts arise as a means of economizing on monitoring costs.

The model was used to study business cycle behavior across alternative exchange rate regimes, in the context of technological and monetary disturbances. Under a particular exchange rate regime, variances and covariances depend on the deep parameters of the model, i.e., on the transactions costs and monitoring costs faced by the economic agents in the environment. Since these deep parameters are also what determine the equilibrium financial structure, the model defines a mapping from financial structure to business cycle phenomena. This mapping changes with the exchange rate regime.

The model's predictions conform generally to conventional views concerning the international transmission of business cycles. Comovements among national outputs, inflation rates, and interest rates are positive and qualitatively unaffected by the exchange rate regime. In addition, technological (monetary) disturbances induce a negative (positive) correlation between inflation and output. A flexible exchange rate regime where the domestic money stock is fixed may or may not yield a lower output variance than the fixed exchange rate systems considered, depending on the source of disturbances.

Part of the novelty in this approach comes from the fact that the model has a rich structure of heterogeneity among economic agents who have simple preferences, in contrast to the widely used representative agent paradigm, in which identical agents possess more complex preferences [see Kimbrough (1987), for a survey]. It is hoped that the model constructed here will be useful in other international finance applications, perhaps in a form that achieves an integration with representative agent approaches.

Footnotes

[1]See also Camen (1987).

[2]The overlapping generations model has not seen much use as a monetary paradigm in international economics, with two exceptions being Kareken and Wallace (1981) and Freeman and Murphy (1988).

[3]For example, we might suppose that some group of agents in the model do not have an endowment or access to a technology, and always repudiate their debts. Part of the cost α might be a cost of distinguishing these agents from other agents who do not repudiate.

[4]The legal restriction that agents cannot hold the other country's currency across periods is a portfolio restriction only. This does not restrict within-period transactions, which in some interpretations of the model are carried out using currency (domestic, foreign, or both). Note, however, that in contrast to what occurs in cash-in-advance models, these within-period transactions do not require currency.

[5]It would make no difference for the subsequent analysis if monetary and real shocks were independent, with each following a two-state Markov process.

[6]The output expansion occurs in the period after the interest rate movement, but the correlation is contemporaneous and of the same sign if disturbances are positively serially correlated ($q_1 > q_2$).

[7]Formulae for standard deviations are algebraically simpler than for variances.

[8]For a discussion of some strategic issues associated with macroeconomic policymaking in open economies, see Kehoe (1987).

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Table 1

Signs of Covariances With y_{t+1} Under
Alternative Exchange Rate Regimes*

	Technology Shocks			Foreign Money Shocks		
	(a)	(b)	(c)	(a)	(b)	(c)
y^*_{t+1}	+	+	+	+	+	+
π_t	-	-	-	+	+	+
π^*_t	-	-	-	+	+	+
ϵ_t	?	0	0	-	0	0
b_t	?	?	?	+	?	?
r_t	+	+	+	-	-	-

<u>Note</u>: (a) = flexible exchange rate regime
(b) = fiscal policy peg exchange rate regime
(c) = monetary policy peg exchange rate regime