International Financial Intermediation and Aggregate Fluctuations Under Alternative Exchange Rate Regimes

Greenwood, Jeremy and Stephen D. Williamson

Working Paper No. 120
February 1988

International Financial Intermediation and Aggregate Fluctuations under Alternative Exchange Rate Regimes

Jeremy Greenwood and Stephen D. Williamson

Rochester Center for Economic Research
Working Paper No. 120

INTERNATIONAL FINANCIAL INTERMEDIATION AND AGGREGATE FLUCTUATIONS UNDER ALTERNATIVE EXCHANGE RATE REGIMES

Jeremy Greenwood*
University of Western Ontario, London, Canada N6A 5C2
Rochester Center for Economic Research, Rochester, NY 14627

Stephen D. Williamson*
Federal Reserve Bank of Minneapolis, Minneapolis, MN 55480

Working Paper No. 120

February 1988

* We thank seminar participants at Boston College, the Federal Reserve Bank of Minneapolis, the National Bureau of Economic Research, and the University of Western Ontario for their comments. We assume responsibility for any remaining errors. Financial support from the Social Sciences and Humanities Research Council of Canada is gratefully acknowledged. The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

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 economic development and to examine 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.

1. Introduction

This paper is appropriately viewed as a contribution to the study of the consequences of international capital mobility. Though financial intermediaries that borrow and lend internationally clearly play an important role in providing capital mobility, previous work has omitted an explicit treatment of the intermediation process among countries. This omission came about mainly because, until recently, no rigorous theories of financial intermediation existed. However, work by Boyd and Prescott (1986), Diamond (1984), and Williamson (1986), among others, has made some progress on this front. This work, in addition to leading to applications which show how the intermediation process can be modeled in a macroeconomic setting (see, for example, Williamson 1987b), permits a deeper examination of how intermediation affects international capital mobility, exchange rate determination, relative incomes across countries, and business cycle phenomena.

In this paper, 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, 1987b). 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.

The core of the model, aside from the intermediary structure, is an overlapping generations framework which shares some features of an example with borrowing and lending in Wallace (1980). The overlapping generations model has not seen much use as a monetary paradigm in international economics, with two exceptions being work by Kareken and Wallace (1981) and Freeman and Murphy (1987). The alternative approach, favored in much recent work, is the cash-in-advance model (see Helpman 1981, Lucas 1982, and Stockman and Svensson 1987). The overlapping generations framework is used here for two reasons: first, it is convenient as a vehicle for embedding an intermediary structure in a dynamic macroeconomic model; second, it highlights the role of trading frictions in determining exchange rates (see Kareken and Wallace 1981) and the effects of the policy regime (here, the exchange rate regime) on the degree of substitutability among assets.

Some of the results in the paper have as much to do with the monetary paradigm adopted as with the explicit role for intermediation in the model. For example, the exchange rate matters in part because money matters in an overlapping generations model; that is, money permits an expansion in trading possibilities, and anticipated money growth is in general non-neutral. In other ways, however, the roles of money and intermediation are inextricably linked in generating the results. In particular, transactions costs and monitoring costs permit a financial structure with observable features. But these same costs are important, first, in yielding predictions consistent with the facts of economic development and, second, in producing business cycle behavior.

Once the model is constructed, its implications for long-run phenomena are examined in a deterministic setting. First, it is shown that higher money growth and inflation is associated with higher per capita income because of a credit allocation mechanism which provides a direct link from credit to investment and output. Then, three types of exogenous technological improvements are considered: a change in the stochastic investment technology, a change in the transactions cost technology, and a change in monitoring costs. Together, the results of these three experiments are consistent with some stylized facts concerning economic development that have been documented by Townsend (1983), Lucas (1985), and Romer (1986). In particular, differences in per capita income levels across countries can persist over time. Also, the fraction of wealth held in the form of intermediated assets relative to the fraction held in currency tends to increase as per capita income increases, both over time and in a cross section of countries.

Business cycle fluctuations due to technological and monetary disturbances are then examined under three alternative exchange rate regimes: a flexible exchange rate regime and two regimes with a fixed exchange rate. The first fixed exchange rate regime is a fiscal policy peg, where monetary policy is held constant; the second fixed exchange rate regime is a monetary policy peg, where fiscal policy is held constant. Under the three regimes, business cycle phenomena are qualitatively similar but quantitatively different. Interest rates are procyclical in response to real shocks and countercyclical in response to monetary shocks, with the inflation rate in each country exhibiting the opposite cyclical pattern. Consistent with stylized facts, interest rates, incomes, and inflation rates are positively correlated across countries over the business cycle.

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.

This paper is related to the real business cycle literature which introduces nonconvexities into labor supply decisions (see Hansen 1985 and Greenwood and Huffman 1987). In the model developed here, there is a nonconvexity in the decision to finance an investment project, since investment projects are technologically indivisible. However, our framework differs in that, due to informational asymmetries, agents cannot insure themselves against the event that their investment project is not financed. Also, by assumption, the usual avenue through which impulses are propagated in real business cycle models--intertemporal substitution--is closed off in this model. This feature helps highlight the role of the credit allocation mechanism (see Williamson 1987b) in the model, the mechanism by which investment and output fluctuate over the business cycle due to monitoring costs, asymmetric information, and the nonconvexity in investment decisions.

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. A closed-economy model with similar features is constructed by Williamson (1987b), 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 given generation (note that two generations are alive at each date) who live in the foreign country, who are entrepreneurs, and who have $\beta \leq \beta'$.

At $t = 1$, old agents are 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 financial intermediary.) If an agent is a lender, she must expend α units of effort 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.[1] 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 $E_t(c_t-\ell_t-\ell_{t+1})$, 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 independently and identically distributed 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 $E_t(c_{t+1})$.

Note that the transactions cost α is particular to the lender and is a cost to which the lender commits herself, ex ante. In contrast, the monitoring cost β is particular to an entrepreneur, and other agents have discretion, ex post, as to whether they incur this cost, though a contractual arrangement may commit an agent to monitoring under certain contingencies.

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. There are no government purchases. 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 in the environment considered here, 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.[2] Legal restrictions are sufficient here to assure exchange rate determinacy. However, note that the transactions costs faced by lenders are also important in this respect. If $\alpha = 0$ for every lender, then each fiat money would be a perfect substitute for intermediated credit and the exchange rate would be indeterminate, even with legal restrictions.

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 (1986,1987b) 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 the lowest (i.e., virtually zero) transactions cost. 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 1986,1987b), it is optimal for the intermediary to write a debt contract 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 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 maximum 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 $\beta \leq \beta_t'$ receives a loan with a gross interest payment of x, as specified by (2.2). Consequently, there is a sense in which credit rationing occurs in equilibrium (as discussed at greater length in Williamson 1986, 1987a). Note that the nonconvexity in the investment technology is necessary for this result. 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 $r_t - \alpha \geq E_tp_{t+1}/p_t$, 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 $\alpha = r_t - E_tp_{t+1}/p_t$. An equilibrium condition for the home-country market for fiat money is then

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

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

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

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 $\Pi^*(\beta'_t,\theta_t) = \Pi(x'_t,\beta'_t,\theta_t) = r_tK$, 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:

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

and

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

The equilibrium condition for the world credit market is then

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

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. This version of the model is examined for two reasons. First, it may be easier for the reader to understand the forces at work in the model in a deterministic setting before proceeding to business cycle fluctuations. Second, it is more straightforward in this version to show how the model explains the role of financial intermediation in international growth and development, and how the model can generate predictions consistent with some stylized facts of economic growth.

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 $p_tM_t = q$ and $p^*_tM^*_t = q^*$, 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

$$\eta\gamma[1-F(r-1/z)] = p_1M_1 \tag{4.3}$$

$$(1-\eta)\gamma^*[1-F^*(r-1/z^*)] = p^*_1M^*_1 \tag{4.4}$$

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

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

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

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 $t = 2, 3, 4, \ldots$, 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, four exercises in comparative statics will be performed to examine the effects of once-and-for-all exogenous changes on interest rates, intermediation activity, and per capita incomes. The first experiment is 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)-(4.8), 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.

For the second experiment, 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 our model because of the effect of the credit allocation mechanism on output (see Williamson 1987b). This credit allocation mechanism provides a direct link from credit to investment and output.

For the last two experiments, which involve shifts in the distribution functions of transactions and monitoring costs, suppose that G and G^* are members of the same family of distributions $\tilde{G}(\beta;\psi)$, parameterized by ψ. Specifically, let $G(\beta) = \tilde{G}(\beta;\psi_1)$ and $G^*(\beta) = \tilde{G}(\beta;\psi_2)$, with $D_2\tilde{G}(\beta;\psi) < 0$, so that ψ orders distributions according to first-order stochastic dominance. In a similar fashion, assume that there is a family of distributions $\tilde{F}(\alpha;\phi)$, where $F(\alpha) = \tilde{F}(\alpha;\phi_1)$ and $F^*(\alpha) = \tilde{F}(\alpha;\phi_2)$, with $D_2\tilde{F}(\alpha;\phi) < 0$.

For experiment three, consider the implications of an increase in ψ_1. Such a shift effectively reduces the creditworthiness of domestic entrepreneurs in the sense that it concentrates them more heavily in the range with high monitoring costs. The following results then obtain:

$$\frac{dr}{d\psi_1} < 0, \ \frac{d\beta'}{d\psi_1} > 0, \ \frac{dy}{d\psi_1} < 0, \text{ and } \frac{dy^*}{d\psi_1} > 0.$$

Note that an increase in ψ_1 reduces the size of the pool of domestic entrepreneurs who receive loans for each value of the interest rate; the world demand for loans and the world interest rate both decrease. In equilibrium, fewer domestic entrepreneurs receive loans, but a greater number of foreign entrepreneurs have their projects funded. As a consequence, the gap between foreign and domestic income, $y^* - y$, widens. Hence, the less creditworthy are domestic entrepreneurs, the more limited will be their participation in international credit markets, and the lower will be domestic income, both relatively and absolutely.

For the fourth and last experiment, suppose ϕ_1 increases. The following results are obtained:

$$\frac{dr}{d\phi_1} > 0, \ \frac{d\beta'}{d\phi_1} < 0, \ \frac{dy}{d\phi_1} < 0, \text{ and } \frac{dy^*}{d\phi_1} < 0.$$

Here, the pool of domestic savers who can profitably access international capital markets at any given world interest is reduced, since the distribution of domestic savers has shifted toward those with higher ex ante transactions costs. The world interest rate must then rise to clear the international credit market. As a result, fewer investment projects are funded worldwide, and income falls in <u>both</u> countries.

Now, one might ask what the preceding experiments (excluding the second, or monetary shock, experiment) tell us about the role of financial intermediation in international growth and development, and how the predictions of the model conform with empirical facts. First, experiments one, three, and four all associate a higher level of per capita income in a particular country with a larger per capita quantity of intermediated capital in that country. Second, experiment three indicates that relative per capita incomes are determined by the relative quality of entrepreneurs in each country. Third, experiment four shows that the fraction of wealth held in the form of intermediated assets versus currency in a country is determined by the transactions costs faced by lenders. Note that experiments one, three, and four all associate technological improvements--whether in the investment technology, the monitoring technology, or the transactions technology--with increases in per capita world income and in the fraction of worldwide wealth which is intermediated. Clearly, these kinds of technological changes encompass a great deal, including improvements in the legal environment (affecting monitoring costs) and in communications and transportation (affecting transactions costs).

The above predictions are consistent with some stylized facts of economic growth documented by Lucas (1985), Romer (1986), and Townsend (1983). In particular, differences in measured per capita income can persist across countries, as is shown by experiment three (see Lucas 1985). Also, the fraction of intermediated assets relative to currency in total wealth tends to increase with per capita income. This occurs in the time series as well as in the cross section, as documented by Townsend (1983), so long as improvements in the transactions technology are associated with other technological improvements.

5. Equilibrium with aggregate fluctuations

In this section, aggregate fluctuations are studied which are caused by real disturbances affecting the 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 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 two extremes have their own logic in terms of the environment in which the home government operates here. Also, they seem to correspond to real-world policy alternatives, though perhaps not to alternatives usually considered in the international finance literature. In this regard, 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, though 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.

For simplicity, suppose that there are only two states, $s_t = 1, 2$, 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 $i = 1, 2$.[3] Given the above transition probabilities governing movements between states, the associated limiting probabilities for the occurrence of each state are

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

In what follows, attention will be restricted to stationary monetary equilibria, where interest rates and quantities depend only on s_t and where $p_t > 0$, 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 gross 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, we have

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

$$\pi_{22}^* = 1/z_2^* \tag{5.2}$$

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

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

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)-(5.4):

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

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

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

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

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

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

Here, subscripts on variables denote states so that, for example, r_i is the deposit interest rate when $s_t = i$. Equations (5.1)-(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), per capita income in each country is 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

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

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

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), we have

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

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

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

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

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 where 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 limiting covariance is

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

(as in Williamson 1987b). To find the covariance for a small perturbation to the benchmark equilibrium, a second-order Taylor expansion of expression (5.22) gives

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

where $\omega = \theta_i, z_i^*$, for $i = 1, 2$. In computing covariances when a_t or b_t, or both, depend not just on s_t but 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, and $a_t^e = E_t a_t$, then direct computation gives

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

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 relevant results are summarized as follows:

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

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

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

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

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

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

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

where

$$F \equiv F(r-1)$$

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

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

$$\nabla \equiv H\left[\eta\gamma f a^*(1-F)+(1-\eta)\gamma^* f^* a(1-F^*)\right]$$

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

$$a \equiv (1-q_1+q_2)f + (1-F)$$

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

With the more favorable distribution of investment returns available in state 2, the world demand for credit is higher in state 2 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 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. Similarly, 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

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

In terms of the distribution $F(\cdot)$, $f/(1-F)$ 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. Therefore, 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 <u>both</u> savers and entrepreneurs [see equation (5.31)].

An analysis of fluctuations under monetary disturbances is now carried out by considering 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 by

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

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

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

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

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

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

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

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

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

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. This result can be contrasted with the properties of a static two-country Mundell-Fleming model (of the type discussed in Mundell 1968, pp. 262-271), where a monetary expansion in one country <u>reduces</u> output in the other country. In this sense, the predictions of the model analyzed here show a greater degree of conformity with observations. More recent work with sticky price models by Svensson and Wijnbergen (1987) shows that this Mundell-Fleming result can be overturned in a Keynesian-type model, but this depends on the size of the intertemporal elasticity of substitution relative to the intratemporal elasticity between home and foreign goods.

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), and (5.32)-(5.35), 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. Then, 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 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. Other differences between the predictions of this model and of Mundell-Fleming models were noted above. 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.[4]

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, from (3.2)-(3.8) the equilibrium conditions for this exchange rate regime are (5.8), (5.9), and

$$1 - F^*\big(r_1 - q_1 - (1-q_1)/\pi_{12}z^*_2\big) - \pi_{12}\big[1 - F^*\big(r_2 - q_2\pi_{12} - (1-q_2)/z^*_2\big)\big] = 0 \tag{5.41}$$

$$\eta\gamma F\big(r_1 - q_1 - (1-q_1)/\pi_{12}z^*_2\big) + (1-\eta)\gamma^* F^*\big(r_1 - q_1 - (1-q_1)/\pi_{12}z^*_2\big)$$
$$= \eta(1-\gamma)KG(\beta'_1) + (1-\eta)(1-\gamma^*)KG(\beta'_1) \tag{5.42}$$

$$\eta\gamma F\big(r_2 - q_2\pi_{12} - (1-q_2)/z^*_2\big) + (1-\eta)\gamma^* F^*\big(r_2 - q_2\pi_{12} - (1-q_2)/z^*_2\big)$$
$$= \eta(1-\gamma)KG(\beta'_2) + (1-\eta)(1-\gamma^*)KG(\beta'_2). \tag{5.43}$$

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

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

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

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

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

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

Following the same procedure used for the flexible exchange rate regime and using (5.8), (5.9), and (5.41)-(5.46), the equilibrium effects of technological disturbances are given by

$$\frac{d\beta_1'}{d\theta_2} - \frac{d\beta_2'}{d\theta_2} = \frac{-\delta\left[\eta\gamma f + (1-\eta)\gamma^* f^*\right](1-F^*)}{\Sigma} < 0 \qquad (5.47)$$

$$\frac{dr_1}{d\theta_2} - \frac{dr_2}{d\theta_2} = \frac{-\delta a^* K\left[\eta(1-\gamma)g + (1-\eta)(1-\gamma^*)g^*\right]}{\Sigma} < 0 \qquad (5.48)$$

$$\frac{d\pi_{12}}{d\theta_2} = -\frac{f^*}{a^*}\left[\frac{dr_1}{d\theta_2} - \frac{dr_2}{d\theta_2}\right] > 0 \qquad (5.49)$$

$$\frac{db_1}{d\theta_2} - \frac{db_2}{d\theta_2} = \frac{\eta\delta K(1-\eta)(1-F^*)\left[-(1-\gamma)\gamma^* g f^* + \gamma(1-\gamma^*) f g^*\right]}{\Sigma} \gtrless 0 \qquad (5.50)$$

where

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

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). From (5.29) and (5.47), income at t + 1 is highest in each country when $s_t = 2$. However, given (5.31) and (5.50), it is possible that the capital account might move differently across states in this regime compared to the flexible exchange rate system.

For monetary disturbances, the results are summarized by

$$\frac{d\beta_1'}{dz_2^*} - \frac{d\beta_2'}{dz_2^*} = - \frac{(q_1-q_2)\left[\eta\gamma f+(1-\eta)\gamma^* f^*\right](1-F^*)K}{\Sigma} < 0 \tag{5.51}$$

$$\frac{dr_1}{dz_2^*} - \frac{dr_2}{dz_2^*} = - \frac{H}{K}\left[\frac{d\beta_1'}{dz_2^*} - \frac{d\beta_2'}{dz_2^*}\right] > 0 \tag{5.52}$$

$$\frac{d\pi_{12}}{dz_2^*} = \frac{f^*(q_1-q_2)K^2\left[\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*\right]}{\Sigma} > 0 \tag{5.53}$$

$$\frac{db_1}{dz_2^*} - \frac{db_2}{dz_2^*} = \frac{\eta(1-\eta)(q_1-q_2)K^2(1-F^*)\left[-\gamma^*(1-\gamma)f^*g+\gamma(1-\gamma^*)fg^*\right]}{\Sigma} \gtrless 0. \tag{5.54}$$

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. From (5.31), (5.38), (5.50), and (5.54), observe that the capital account may move differently across states in response to monetary and real shocks under the flexible exchange rate regime, but that this is not the case here. Rather, 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.

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.) These asset exchanges, in contrast to the fiscal policy peg, 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). 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 $t \to \infty$.

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

$$\begin{aligned} &\eta\gamma\left[1-F\left(r_1-q_1-(1-q_1)/\pi_{12}z_2^*\right)\right] - \eta\gamma\pi_{12}\left[1-F\left(r_2-q_2\pi_{12}-(1-q_2)/z_2^*\right)\right] \\ &\quad + (1-\eta)\gamma^*\left[1-F^*\left(r_1-q_1-(1-q_1)/\pi_{12}z_2^*\right)\right] \\ &\quad - (1-\eta)\gamma^*\pi_{12}\left[1-F^*\left(r_2-q_2\pi_{12}-(1-q_2)/z_2^*\right)\right] = 0. \end{aligned} \tag{5.55}$$

Equation (5.55) is the market-clearing condition for fiat money. Incomes in each country and home-country borrowing are given by (5.11), (5.12), (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 <u>laissez-faire</u> regime. Most economists, including Friedman (1953), view a flexible exchange rate regime as a noninterventionist system, but that view neglects the underlying portfolio restrictions which make such a system feasible (see Kareken and Wallace 1981).

Using (5.8), (5.9), (5.42), (5.43), and (5.55), the equilibrium effects of technological disturbances are then given by

$$\frac{d\beta_1'}{d\theta_2} - \frac{d\beta_2'}{d\theta_2} = \frac{-\delta[\eta\gamma f+(1-\eta)\gamma^*f^*][\eta\gamma(1-F)+(1-\eta)\gamma^*(1-F^*)]}{\Psi} < 0 \tag{5.56}$$

$$\frac{dr_1}{d\theta_2} - \frac{dr_2}{d\theta_2} = \frac{-\delta K[\eta\gamma a+(1-\eta)\gamma^*a^*][\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*]}{\Psi} < 0 \tag{5.57}$$

$$\frac{d\pi_{12}}{d\theta_2} = -[\frac{\eta\gamma f+(1-\eta)\gamma^*f^*}{\eta\gamma a+(1-\eta)\gamma^*a^*}][\frac{dr_1}{d\theta_2} - \frac{dr_2}{d\theta_2}] > 0 \tag{5.58}$$

$$\frac{db_1}{d\theta_2} - \frac{db_2}{d\theta_2} = \eta\delta(1-\eta)[\eta\gamma(1-F)+(1-\eta)\gamma^*(1-F^*)]$$

$$\times \frac{[-(1-\gamma)\gamma^*f^*g+\gamma(1-\gamma^*)fg^*]}{\Psi} \gtrless 0 \tag{5.59}$$

where

$$\Psi \equiv H[\eta\gamma f+(1-\eta)\gamma^*F^*][\eta\gamma(1-F)+(1-\eta)\gamma^*(1-F^*)]$$

$$+ K^2[\eta\gamma a+(1-\eta)\gamma^*a^*][\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*].$$

The qualitative comovements among incomes, real interest rates, inflation, and the current account are identical in this and the fiscal peg regime, though there are quantitative differences.

For the case of monetary disturbances, the following results are obtained:

$$\frac{d\beta_1'}{dz_2^*} - \frac{d\beta_2'}{dz_2^*} = \frac{-(q_1-q_2)K[\eta\gamma f+(1-\eta)\gamma^* f^*][\eta\gamma(1-F)+(1-\eta)\gamma^*(1-F^*)]}{\Psi} < 0 \qquad (5.60)$$

$$\frac{dr_1}{dz_2^*} - \frac{dr_2}{dz_2^*} = -\frac{H}{K}\left[\frac{d\beta_1'}{dz_2^*} - \frac{d\beta_2'}{dz_2^*}\right] > 0 \qquad (5.61)$$

$$\frac{d\pi_{12}}{dz_2^*} = \frac{(q_1-q_2)K^2[\eta\gamma f+(1-\eta)\gamma^* f^*][\eta(1-\gamma)g+(1-\eta)(1-\gamma^*)g^*]}{\Psi} > 0 \qquad (5.62)$$

$$\frac{db_1}{dz_2^*} - \frac{db_2}{dz_2^*} = \eta(q_1-q_2)(1-\eta)K^2[\eta\gamma(1-F)+(1-\eta)\gamma^*(1-F^*)] \times \frac{[-(1-\gamma)\gamma^* f^* g+\gamma(1-\gamma^*)fg^*]}{\Psi}. \qquad (5.63)$$

As with real disturbances, the qualitative comovements produced by monetary disturbances are the same as in the fiscal peg regime.

6. Variability under alternative exchange rate regimes

The results of section 5 are consistent with stylized facts in that (1) business cycle phenomena are qualitatively similar across different exchange rate regimes and (2) incomes, interest rates, and inflation rates tend to move together across countries over the cycle. Clearly, however, quantitative comovements among macroeconomic time series differ across exchange rate regimes in the model, and it would be interesting to make comparisons. In principle, the variance-covariance matrix for a vector which included all variables of interest could be compared across regimes. However, since this would be taxing on space and the reader's patience, attention is confined here to a comparison of the variance of income and the interest rate under 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, where 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.[5]

6.1. Real disturbances

Under small real disturbances, and using (5.25), (5.47), and (5.56), 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

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

with the same proportionality factor in each case. 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

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

Using (5.26), (5.48), and (5.57), relative income and real interest rate standard deviations are related as follows:

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

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 variability 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, and using (5.32), (5.33), (5.46), (5.51), (5.52), and (5.61), the following results are obtained:

Flexible versus fiscal peg

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

Flexible versus monetary peg

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

Fiscal peg versus monetary peg

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

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, since the proportionality factor is the same for each of the relative income standard deviations, and given (6.5), 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 the 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 (6.6)-(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. One approach to welfare analysis in this stochastic environment would be to rank exchange rate regimes according to a Pareto criterion. That is, regime m Pareto-dominates regime m' if, for any path followed by s_t, all agents achieve higher expected utility, conditional on the path of s_t up to their birth, in regime m than in regime m'. A local welfare analysis could then be carried out--one analogous to the local analysis of the model's variance-covariance properties done here. A reasonable conjecture is that the three exchange rate regimes cannot be Pareto-ranked in this manner. Note in particular (omitting the effect of government transfers on welfare) that 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 clearly 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)]. In this regard the properties of the model are broadly similar to those of Mundell-Fleming models with perfect capital mobility (see Mundell 1968) and some of the intuition is similar. It should be emphasized, however, that this similarity in predictions should not lead one to prefer the older (and perhaps simpler) approach, for in some cases it would be misleading. For example, the approach here provides an insight into how different exchange rate regimes generate different patterns of substitutability among assets. This insight is missed if asset demand functions are taken as primitives. (See Sargent 1982 for a discussion of how this difference in approaches can be critical in answering some questions.)

Some comments are in order about how these results relate to those in other recent work comparing alternative exchange rate regimes. In 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. In contrast, the exchange rate system matters here because money is not 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. The importance of this feature in their version is that anticipated changes in money growth are not neutral (see also Stockman 1985 and Greenwood and Huffman 1987). Note, however, that the mechanism by which money affects output in Aschauer and Greenwood (1983) is different from the forces at work in this model. In their framework, an increase in money growth and inflation acts as a tax on labor effort, and output falls; while in this model the same disturbance causes portfolio substitution into intermediated credit, and output increases.

7. Conclusions

Rather than summarizing results, this section concludes the paper by discussing two issues of note. First, since an important feature of the model (and a novel one, in terms of the international finance literature) is the explicit role it provides for financial intermediation, a discussion of the relationship between this role for intermediation and the phenomena studied here is pertinent. Second, some comments are provided on the general usefulness of the paper's modeling approach as it relates to the representative agent paradigm.

The importance of the intermediary structure is most readily apparent in the analysis of the deterministic equilibrium in section 4. This analysis shows that two countries facing the same investment technology can have different (persistent) levels of income and a different composition of wealth if the agents in these countries face different transactions costs and/or if entrepreneurs are more or less costly to monitor in one country than in the other. Transactions costs and monitoring costs, in addition to helping generate steady state behavior consistent with some stylized facts of economic growth, determine important features of the intermediary structure. In particular, diversified intermediaries that write debt contracts arise as a means of economizing on monitoring costs, and the existence of transactions costs implies that intermediary liabilities dominate fiat money in terms of expected rate of return. Thus, the model's ability to explain long-run facts is integrally related to its ability to endogenously generate an intermediary structure with observed features.

For the business cycle phenomena studied in section 5, the role of the intermediary structure is perhaps less obvious. One might argue that a simpler model without an intermediary structure could produce the same set of business cycle observations, and that intermediation is therefore inessential in accounting for these phenomena. This simpler model might be an overlapping generations model without private information but with a one-period stochastic storage technology subject to aggregate decreasing returns to scale. This alternative model would generate a variance-covariance structure for the endogenous variables that would, in part, be determined by parameters characterizing aggregate production technologies. However, the model studied here goes deeper: it produces a variance-covariance structure that depends on the distributions of transactions costs and monitoring costs across agents. Thus, with the approach here, more insight is gained about the underlying processes that play a role in fluctuations. In addition, the model's intermediary structure permits one to draw a correspondence between model parameters and observables. For example, in equilibrium the transactions costs in the model are literally the costs of transacting with intermediaries.

The model constructed here has a rich structure of heterogeneity among economic agents who have simple preferences. This structure can be contrasted to the more widely used representative agent paradigm, in which agents are identical but possess more complex preferences. This latter approach has recently been popular in international finance, for example, in the work of Aizenman (1983), Greenwood (1983), Helpman and Razin (1982), Obstfeld (1981), and Stockman and Svensson (1987). (For a survey of this literature, see Kimbrough 1987.) In these studies, consumption smoothing and intertemporal substitution are important in explaining comovements among the exchange rate, the trade balance, and other variables. In contrast, in the current model, agent heterogeneity determines patterns of covariation in prices and aggregate quantities. What the approach in this paper buys, at the expense of abstracting from the complexity of individual decision making, is an ability to explain a rich array of observable phenomena, institutions, and patterns of trade. It is hoped that future research can build on this approach, perhaps by integrating what has been learned here with features from representative agent models.[6]

Footnotes

[1]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. Also, α might include check-writing costs of the type incorporated in the framework of Freeman and Huffman (1986).

[2]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.

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

[4]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 ($q_1 > q_2$).

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

[6]See Williamson (1987b) for a model which incorporates elements of agent heterogeneity and intertemporal substitution in a closed-economy framework similar to the one presented here.

References

Aizenman, J., 1983, A theory of current account and exchange rate determination, European Economic Review 23, 261-280.

Aschauer, D. and J. Greenwood, 1983, A further exploration in the theory of exchange rate regimes, Journal of Political Economy 91, 868-875.

Boyd, J. H. and E. C. Prescott, 1986, Financial intermediary-coalitions, Journal of Economic Theory 38, 211-232.

Diamond, D. W., 1984, Financial intermediation and delegated monitoring, Review of Economic Studies 51, 393-414.

Freeman, S. and G. Huffman, 1986, Inside money, output, and causality, Working Paper 8622C, Centre for the Study of International Economic Relations, University of Western Ontario.

Freeman, S. and R. G. Murphy, 1987, Inside money and the open economy, Manuscript, Boston College.

Friedman, M., 1953, The case for flexible exchange rates, in: Essays in positive economics (University of Chicago Press, Chicago) 157-203.

Greenwood, J., 1983, Expectations, the exchange rate, and the current account, Journal of Monetary Economics 12, 543-569.

Greenwood, J. and G. W. Huffman, 1987, A dynamic equilibrium model of inflation and unemployment, Journal of Monetary Economics 19, 203-228.

Hansen, G. D., 1985, Indivisible labor and the business cycle, Journal of Monetary Economics 16, 309-327.

Helpman, E., 1981, An exploration in the theory of exchange-rate regimes, Journal of Political Economy 89, 865-890.

Helpman, E. and A. Razin, 1982, Dynamics of a floating exchange rate regime, Journal of Political Economy 90, 728-754.

Kareken, J. and N. Wallace, 1981, On the indeterminacy of equilibrium exchange rates, Quarterly Journal of Economics 96, 207-222.

Kimbrough, K., 1987, International linkages, exchange rate regimes, and the international transmission process: Perspectives from optimizing models, in: L. Officer, ed., International economics (Klumer Academic Publications, Boston) 119-196.

Lucas, R. E., Jr., 1972, Expectations and the neutrality of money, Journal of Economic Theory 4, 103-124.

Lucas, R. E., Jr., 1982, Interest rates and currency prices in a two-country world, Journal of Monetary Economics 10, 335-359.

Lucas, R. E., Jr., 1985, On the mechanics of economic development, Marshall Lectures, Cambridge University.

Mundell, R. A., 1968, International economics (Macmillan, New York).

Obstfeld, M., 1981, Macroeconomic policy, exchange-rate dynamics, and optimal asset accumulation, Journal of Political Economy 89, 1142-1161.

Romer, P. M., 1986, Increasing returns and long-run growth, Journal of Political Economy 94, 1002-1037.

Sargent, T. J., 1982, Beyond demand and supply curves in macroeconomics, American Economic Review, Papers and Proceedings 72, 382-389.

Stockman, A. C., 1985, Effects of inflation on the pattern of international trade, Canadian Journal of Economics 18, 587-601.

Stockman, A. C. and L. E. O. Svensson, 1987, Capital flows, investment, and exchange rates, Journal of Monetary Economics 19, 171-201.

Svensson, L. E. O. and S. van Wijnbergen, 1987, Excess capacity, monopolistic competition, and international transmission of monetary disturbances, Manuscript, New York University and the World Bank.

Townsend, R. M., 1979, Optimal contracts and competitive markets with costly state verification, Journal of Economic Theory 21, 265-293.

Townsend, R. M., 1983, Financial structure and economic activity, American Economic Review 73, 895-911.

Wallace, N., 1980, The overlapping generations model of fiat money, in: J. H. Kareken and N. Wallace, eds., Models of monetary economies (Federal Reserve Bank of Minneapolis, Minneapolis, MN) 49-82.

Williamson, S. D., 1986, Costly monitoring, financial intermediation, and equilibrium credit rationing, Journal of Monetary Economics 18, 159-179.

Williamson, S. D., 1987a, Costly monitoring, loan contracts, and equilibrium credit rationing, Quarterly Journal of Economics 102, 135-145.

Williamson, S. D., 1987b, Financial intermediation, business failures, and real business cycles, Journal of Political Economy 95, 1196-1216.