Does Exchange Rate Stability Increase Trade and Capital Flows?[1]

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Abstract

On the eve of a major change in the world monetary system, the adoption of a single currency in Europe, our theoretical understanding of the implications of the exchange rate regime for trade and capital flows is still limited. We argue that two key model ingredients are essential to address this question: a general equilibrium setup and deviations from purchasing power parity. By developing a simple benchmark monetary model that contains these two ingredients, we find the following main results. First, the level of trade is not necessarily higher under a fixed exchange rate regime. Second, the level of net capital flows tends to be higher under a fixed exchange rate regime when there is a preference for domestic bonds, which is the case when the rate of relative risk-aversion is larger than one. Third, the asset market structure, including the presence of a forward market, does not qualitatively affect the results.

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"*...under a system of freely fluctuating exchange rates, the world market for goods and capital would be divided. Resource allocation would be vastly suboptimal.*" Kindleberger (1969).

1 Introduction

With hindsight Kindleberger's dismal prediction at the end of the sixties was an overstatement of the damage exchange rate volatility can do. But on the eve of another major change of the world monetary system, a monetary union in Europe, many economists and policy makers still view a stable currency as favorable to trade in goods and capital. The well known 1990 European Community report "One Market, One Money" describes increased trade and capital markets integration as one of the main benefits from adopting a single currency in Europe. Despite this widespread view, the substantial empirical literature examining the link between exchange rate uncertainty and trade has not found a consistent relationship.[1] In papers that do find a negative relationship, it is generally weak.[2]

This discrepancy between the empirical literature and commonly held views on the negative effects of exchange rate uncertainty calls into question the background model used to think about these issues. A main shortcoming of the debate regarding the implications of the exchange rate system for trade and capital flows is the lack of a sound analytical foundation. In particular, these questions have not been cast in a macroeconomic, general equilibrium, framework.[3] Our goal is to develop a benchmark model, incorporating some recent developments in open economy macroeconomics, that allows us to determine the main mechanisms through which the exchange rate regime can affect trade and capital flows. Our strategy is to present a model rich enough to examine the role of the exchange rate system, but at the same time simple enough that the results are highly transparent and can be derived analytically. There are two key model ingredients that we believe are

[1]See Côté (1994) for a survey.

[2]There is evidence that trade is larger within countries than across countries. See for example McCallum (1995). But Wei (1996) finds that exchange rate uncertainty does not play a significant role in the trade home bias.

[3]Obstfeld and Rogoff (1998) come to a similar conclusion. Moreover, they stress the need for "stochastic general equilibrium monetary models" that do *not* "rely on a certainty equivalent assumption to approximate equilibrium relationships".

essential to address the issue: a general equilibrium approach and deviations from purchasing power parity (PPP).

The case for a general equilibrium framework is natural since one cannot look at the exchange rate in isolation. There is now a substantial body of literature showing that at horizons of at least one year there is a close relationship between exchange rates and easily observable fundamentals.[4] The same fundamentals that drive exchange rate fluctuations, such as monetary, fiscal and productivity shocks, affect overall macroeconomic risks faced by firms and households. It is therefore more appropriate to compare different exchange rate systems rather than study the effect of increased exchange rate uncertainty in isolation.[5]

The case for deviations from PPP should also be obvious, given the large observed fluctuations in real exchange rates. We believe that the model should capture some well known stylized facts about real exchange rates: they are more volatile in floating than fixed exchange rate systems, and highly correlated with the nominal exchange rate; the law of one price is grossly violated even for traded goods and deviations from the law of one price are closely related to nominal exchange rate volatility.[6]

Most open economy models do not contain these two ingredients. First, while there exists a literature that investigates the impact of exchange rate uncertainty on trade flows[7], it adopts a partial equilibrium approach. In those models exchange rate uncertainty is usually exogenous in an environment that is otherwise

[4]See Clarida and Gali (1994), Eichenbaum and Evans (1995), Kim and Roubini (1997), MacDonald and Taylor (1994), Mark (1995), Mark and Choi (1997), and Rogers (1998). At very short horizons exchange rate movements often appear unrelated to current measured fundamentals. However, it is only when exchange rate fluctuations are thought to be totally exogenous that a general equilibrium analysis is not needed.

[5]A similar view is found, for example, in Helpman and Razin (1979): "...when discussing a floating exchange rate regime one should consider only exchange rate patterns which fulfil an appropriate market clearing condition. This means that one should not assume...a given distribution of exchange rates, because this distribution is endogenous to the economy". See also Glick and Wihlborg (1996).

[6]Engel (1993) has shown that real exchange rate fluctuations are almost entirely associated with fluctuations in the relative price of identical traded goods across countries.

[7]See Clark (1973), Ethier (1973), Baron (1976), Hooper and Kohlhagen (1978), Cushman (1986), de Grauwe (1988), Viaene and de Vries (1992), Feenstra and Kendall (1991) and Dellas and Zilberfarb (1993).

deterministic. Second, models that take a general equilibrium perspective commonly adopt the PPP assumption, so that the real exchange rate is constant. This is the case, for example, of Helpman (1981), Helpman and Razin (1979, 1982), Lucas (1982), Voss (1998), and Neumeyer (1998), who also examine the impact of the exchange rate regime in general equilibrium. We show that relaxing the PPP assumption significantly affects the results.

Recently progress has been made towards developing general equilibrium models capturing some of the key stylized facts about exchange rates mentioned above. A now popular approach is to assume pricing to market (PTM) in conjunction with Keynesian price rigidity. Betts and Devereux (1996a,b,1997), Chari, Kehoe and McGrattan (1997), Engel (1996), Kollmann (1997), and Tille (1998) have developed such models.[8] Firms can charge different prices for the same good in domestic and foreign markets. They set prices before the exchange rate is known. A change in the exchange rate will then directly affect the price of a good in one country relative to that in another country. This results in a close relationship between nominal and real exchange rates. These models are often used to study the dynamic response of the exchange rate and other macroeconomic variables after a monetary shock. They have not been used to determine what role the exchange rate regime plays in the allocation of resources, particularly as reflected in trade and capital flows. Either a deterministic environment is assumed or uncertainty does not affect decision variables because of linearization.[9] Moreover, although intra-industry trade is present in all these models, it is a dimension that has not been exploited so far.

As in the papers listed above, we develop a two-country monetary general equilibrium model with price rigidity and pricing to market. Beyond that we

[8] Obstfeld and Rogoff (1995) first developed a model aimed at integrating Keynesian price rigidities into an intertemporal general equilibrium model with sound micro foundations. While they do not assume PTM, the central building block of their model, monopolistic competition à la Dixit and Stiglitz (1997), has been adopted in the subsequent literature as well. See also Corsetti and Pesenti (1997), who solve a version of the model in closed form.

[9] Obstfeld and Rogoff (1998), Rankin (1998), and Svensson and van Wijnbergen (1989) develop open economy monetary models with nominal rigidities in truly stochastic environments (without linearization). But all three papers assume purchasing power parity. They also assume perfect risk sharing (asset market completeness) in order to obtain an analytical solution. They do not compare the implications of different exchange rate systems.

keep the model as simple as possible in order to keep it analytically tractable and transparent. In particular, we consider only one and two period versions of the model, do not allow for capital accumulation, and introduce money through a simple cash-in-advance constraint. The model should therefore be considered as a starting point to investigate an important and difficult issue, highlighting the main factors determining the impact of the exchange rate regime.

Trade takes place as a result of monopolistic competition in differentiated goods. If a foreign market is considered riskier than the home market, a risk premium is passed on to foreign consumers through the price. This reduces the level of trade. It is the overall level of risk that matters, not just exchange rate risk. We show that the risk of selling abroad is not necessarily higher and that the use of a forward market in general does not eliminate risk.[10]

To examine net capital flows, it is necessary to introduce country asymmetries. Although this complicates substantially the analysis, we are able to find an analytical solution that illustrates the various effects at work. We show that under standard parameter values exchange rate risk reduces net capital flows.

The remainder of the paper is organized as follows. In section 2 we discuss price setting under uncertainty by a single firm. Section 3 develops a one-period general equilibrium model and compares fixed and floating exchange rate regimes in their implications for price setting and trade flows. We find that both the deviation from PPP and the general equilibrium framework play a key role. On the other hand, the international asset market structure does not qualitatively affect the results. In the benchmark model we focus on monetary shocks, but we consider extensions to fiscal and productivity shocks as well. Section 4 studies a two-period version of the model in order to compare the size of net capital flows under the two exchange rate systems. The final section concludes and provides suggestions for future research. We leave most of the technical details to the Appendix.

[10]We note that in a world with entry and exit costs firms may simply decide not to enter a foreign market if it is riskier. Such a framework could also lead to incomplete exchange rate passthrough, and therefore deviations from the law of one price. See Baldwin (1988) and Kasa (1992). But for our purposes a decision not to enter a foreign market is not fundamentally different from a decision to pass on a risk premium through the price. In both cases it is uncertainty about profits in the foreign market that matters. We therefore abstract from entry and exit decisions.

2 Optimal Price Setting

In the model we consider, a crucial channel for the impact of the exchange rate regime is the behavior of firms, in particular their optimal price setting. To gain intuition, in this section we consider optimum price setting by a single firm and relate our analysis to the existing literature.

Consider a firm setting prices in advance and able to discriminate between the domestic price p and the foreign price p^* in foreign currency. Markets are segmented, so that consumers cannot arbitrage price differentials. The nominal exchange rate is S, so that the foreign price expressed in domestic currency is Sp^*. The firm faces real demands $c(p,x)$ and $c^*(p^*,x^*)$ at home and abroad, where x and x^* represent aggregate factors affecting consumption demand. For convenience, assume that the demand functions have the same constant price-elasticity μ. Finally, the firm has a linear production function, using $1/a$ quantity of labor per unit of output, independently of whether it is sold at home or abroad. It pays a wage rate w. Profits are simply:

$$\Pi = pc + Sp^*c^* - \frac{w}{a}(c + c^*) \tag{1}$$

Without uncertainty, the optimal price rule with a constant markup is well known:

$$p = \frac{\mu}{\mu - 1}\frac{w}{a} \tag{2}$$

If S is normalized to 1, it is obvious that $p^* = p$.

Giovannini (1988) introduces exchange rate uncertainty in this framework and assumes that the firm maximizes expected profits. The exchange rate is the only element of uncertainty facing the firm. In this case the optimal domestic price is still given by (2), and the foreign price is:

$$p^* = \frac{\mu}{\mu - 1}\frac{w}{a}\frac{1}{E(S)} \tag{3}$$

Exchange rate uncertainty has no impact on prices. Only its expected value matters. There is no ex-ante price discrimination: $p = E(Sp^*)$. A crucial assumption for this result is risk neutrality as firms only care about expected profits. If firms are risk averse, exchange rate uncertainty matters and would lead to a price that is higher in the foreign market, as first shown by Baron (1976). This reduces the level of trade.[11] Many authors have shown that trade remains unaffected by exchange rate risk when firms have access to a forward market and the forward discount is zero.[12] In that case (3) still holds.

An important hypothesis underlying all these papers is that the exchange rate is the only source of uncertainty.[13] However, firms typically face other sources of risk that are potentially correlated with exchange rate fluctuations. If we take the view that exchange rate changes are related to fundamentals, then the same variables that drive fluctuations in the exchange rate are also responsible for uncertainty about the wage rate w, the aggregate demand factors x and x^*, and the technology parameter a. Thus, in order to understand the implications of different exchange rate regimes for price setting and trade flows, we need to compare the overall macroeconomic risks faced by firms under different monetary systems.

The firm maximizes the market value of profits $E(q\Pi)$, where q represents the pricing-kernel. It is the value that firms' owners attach to marginal revenue in different states of the world.[14] The pricing-kernel is proportional to the marginal utility of consumption of the firm's owners, which we denote u_c. When all macroeconomic variables are stochastic, optimal prices are:

$$p = \frac{\mu}{\mu - 1} \frac{E(u_c c w/a)}{E(u_c c)} \tag{4}$$

$$p^* = \frac{\mu}{\mu - 1} \frac{E(u_c c^* w/a)}{E(u_c S c^*)} \tag{5}$$

Prices are still equal to a standard markup over unit cost.[15] The latter is now

[11] Hooper and Kohlhagen (1978) consider a somewhat different setup, with both importers and exporters bearing part of the exchange rate risk. When exporters bear most of the risk, exchange rate uncertainty raises the export price and reduces trade. When importers bear most of the risk, exchange rate uncertainty reduces import demand (and therefore trade), and lowers the import price. In general the price effect is therefore ambiguous, but the trade effect is unambiguously negative.

[12] See Ethier (1973), Baron (1976), Viaene and de Vries (1992) and Feenstra and Kendall (1991).

[13] Adam-Mueller (1997) includes both revenue and exchange rate uncertainty.

[14] The pricing-kernel corresponds to the price of state-contingent claims if they are traded (which is not required for the pricing-kernel to exist).

[15] Notice that these equations are similar to those found in dynamic general equilibrium models with PTM, such as Betts and Devereux (1997), Chari, Kehoe and McGrattan (1997) and Kollmann (1997).

written as the certainty equivalent of total labor cost, divided by the certainty equivalent of sales. Equations (4) and (5) show that ex-ante price discrimination can go in either direction, dependent on the nature of the uncertainty. In the following sections we develop a full model that determines the behavior of the variables in (4) and (5).

Introducing a forward market does not change the optimum price equations (4) and (5). When firms take a hedge position of quantity b, we have to add the net profit $b(F - S)$ to (1), where F is the forward rate. This additive term does not affect pricing rules, but affects the stochastic properties of c, c^*, S, and w. The same is the case when adding other internationally traded securities. This again shows that a general equilibrium approach is unavoidable.

3 Prices and Trade Flows in a General Equilibrium Model

In this section we analyze a two-country general equilibrium model incorporating pricing decisions of firms as described in the previous section. This allows us to determine fully the variables influencing prices in equations (4) and (5), as well as trade flows. For simplicity we focus on a one-period version of the model and leave intertemporal considerations for the next section.[16] We first examine the case where uncertainty comes only from monetary shocks. After setting up the model, we compare prices and gross trade flows under fixed and floating exchange rate regimes. We show that both the deviation from PPP and the general equilibrium framework play a key role. Finally, we consider the role of the asset market structure and other sources of uncertainty (productivity and fiscal shocks).

3.1 A Benchmark Monetary Model

The world is composed of households, firms, and a government in each country, Home and Foreign. Households decide their optimal level of consumption, labor supply and money holdings. Money is held through cash-in-advance constraints.

[16] Betts and Devereux (1996a) and Engel (1996) also examine a one-period model, but do not consider uncertainty.

Firms sell differentiated products at home and abroad and are monopolistically competitive as in Dixit and Stiglitz (1977). There is a continuum of goods and firms in each country. We assume that firms in the Home country produce goods on the interval [0,1], while those in the Foreign country produce goods on the interval [1,2]. Firms need to set their prices in both markets before uncertainty about each country's money supply is resolved. A Home-country firm i sets a price $p_H(i)$ for the Home market and $p_H^*(i)$ for the Foreign market. A Foreign-country firm i sets $p_F^*(i)$ in the Foreign market and $p_F(i)$ in the Home market. Finally, there is a government issuing money randomly and dealing with taxes and transfers. We describe each of these sectors in the Home country; Foreign country agents have a similar behavior.

3.1.1 Money and the government

The Home government provides a random money transfer M to Home residents. Foreign residents receive a random M^* from their government. Under a flexible exchange rate, money supplies are generally different. We assume that the distribution of M and M^* is jointly symmetric, with a correlation less than one. Under a fixed exchange rate the unconditional distributions of the money supplies are the same as under a float, but their correlation is one, i.e., $M = M^*$. Finally, we assume that the government imposes a tax of M at the end of the period, after all transactions are made. This assumption, which is standard for finite horizon models with cash-in-advance constraints, is needed to insure that sellers of goods are willing to accept money.

3.1.2 Households

There is a continuum of identical households with population normalized to one. A representative household consumes all varieties of goods on the interval [0,2], supplies labor, and holds money through cash-in-advance constraints. It also owns a proportion of domestic firms and receives its profits. A representative household maximizes expected utility

$$E\,U(c,l) \tag{6}$$

where E is the expectation operator, l is leisure and c is a CES consumption index:

$$c = \left[\int_0^2 c(i)^{\frac{\mu-1}{\mu}} di \right]^{\frac{\mu}{\mu-1}} \tag{7}$$

Here $c(i)$ is consumption of good i and μ is the elasticity of substitution between any two goods, which must be larger than one. μ is also the price-elasticity of demand, as in Section 2.

With a wage rate of w, and a time endowment of 1, labor income is $w(1-l)$. Firm profits earned by the household are denoted Π. In each state of the world, the household budget constraint is (we omit the state of the world index for convenience):

$$\int_0^1 p_H(i)c(i)di + \int_1^2 p_F(i)c(i)di = w(1-l) + \Pi \equiv Y \tag{8}$$

We refer to the right hand side of (8) as total nominal income Y of the household. In equilibrium, all firms' income is distributed to households, so that Y also denotes nominal output.

The first order conditions for consumption and leisure can be written as

$$u_c \frac{w}{P} = u_l \tag{9}$$

$$c(i) = \frac{1}{2} \left(\frac{p_H(i)}{P} \right)^{-\mu} \frac{Y}{P} \quad (i \leq 1) \tag{10}$$

Here u_c and u_l are the marginal utilities of consumption and leisure. Equation (9) represents the standard trade-off between consumption and leisure. Equation (10) shows the demand for domestic good i as a function of the relative price and real income. Demand for the Foreign good i is similar, with the price $p_H(i)$ replaced by $p_F(i)$. P is the overall consumer price index, defined as

$$P = \left(\frac{1}{2} \int_0^1 p_H(i)^{1-\mu} di + \frac{1}{2} \int_1^2 p_F(i)^{1-\mu} di \right)^{1/(1-\mu)} \tag{11}$$

We now turn to the description of monetary flows. We assume that households need to carry cash before they go to the goods market. Moreover, we assume that households need to use the seller's currency.[17] Since Home households receive

[17]Whether households use the seller's or the buyer's currency influences the nature of money demand. For convenience, we only examine the seller's currency case. However, it can be easily shown that the two cases coincide in this subsection, where there are no internationally traded assets.

Home money M, while Foreign residents receive Foreign money M^*, both domestic and foreign households need to go to the foreign exchange market before buying their goods.

Since the cash-in-advance constraints are binding, the quantity Y sold in equilibrium by Home firms is equal to the total stock of Home money M (which is held by both Home and Foreign households). Home money market equilibrium is therefore represented by

$$Y = M \tag{12}$$

More generally, one can think of M as representing both money supply and money demand shocks. For our purposes these are indistinguishable.[18]

3.1.3 Firms

The behavior of firms is similar to that described in Section 2. We assume at this stage that they are owned by domestic consumers. Since there are no productivity shocks in the benchmark model, we set $a = 1$. Using the notation introduced in this section, profits of a Home firm i (in each state of the world) are given by

$$\Pi = p_H(i)c(i) + Sp_H^*(i)c^*(i) - w(c(i) + c^*(i)) \tag{13}$$

Home demand is given by (10), using (12). Foreign demand is given analogously by:

$$c^*(i) = \frac{1}{2}\left(\frac{p_H^*(i)}{P^*}\right)^{-\mu}\frac{M^*}{P^*} \tag{14}$$

with the foreign price index P^* defined similarly to (11).

Firms decisions are taken in two stages. First they announce prices p_H and p_H^* before households receive their money transfer. They do not change their price after knowing money supplies because of (prohibitive) menu costs. Second, they decide on labor input after knowing the state of the world. The latter decision is simply determined by the demand for goods.

[18] Our assumptions imply that the correlation of output across countries falls when they switch to a floating exchange rate system. This is consistent with the evidence of Baxter and Stockman (1989) who find that the correlation of output among OECD countries is lower in the post 1973 period (1973-1985) than the pre-1973 period (1960-1970).

In setting prices, firm i maximizes the market value of profits, $E(u_c \Pi)$, subject to domestic and foreign demand for their goods, (10) and (14). Optimal prices are:

$$p_H(i) = \frac{\mu}{\mu - 1} \frac{E\, u_c w M}{E\, u_c M} \tag{15}$$

$$p_H^*(i) = \frac{\mu}{\mu - 1} \frac{E\, u_c w M^*}{E\, u_c S M^*} \tag{16}$$

These are applications of (4) and (5) to the benchmark monetary model. Since all domestic firms charge the same price in equilibrium, we refer to these prices as p_H and p_H^*. Similarly, we define consumption of domestic goods as $c_H = c(i)$ and $c_H^* = c^*(i)$ for $0 < i < 1$.

We finally need to solve for the equilibrium exchange rate. This follows from the money market equilibrium condition $M = Y = p_H c_H + S p_H^* c_H^*$. After substituting the demand functions for domestic goods, we can solve[19]

$$S = \frac{M}{M^*} \tag{17}$$

The symmetric structure of the model implies that the nominal exchange rate is equal to the ratio of money supplies. This is clearly a very simplistic exchange rate equation, even if one takes account of the fact that M can also represent money demand shocks. What matters though is that it captures in a simple way the basic idea that the exchange rate is connected to underlying fundamentals, which implies the importance of general equilibrium analysis. Uncertainty about the fundamentals (the money supplies) not only leads to uncertainty about exchange rates firms face, but also about wages they pay and demand for their goods.

3.2 Implications for Optimal Prices and Trade

We are now ready to analyze the impact of the exchange rate regime on prices and trade. To examine trade, we consider the value of exports plus imports, divided by GDP. Since exports in Home currency are $S p_H^* c_H^*$ and imports are $p_F c_F$, we can use the demand functions and symmetry to find

$$Trade = \frac{exports + imports}{GDP} = \left(\frac{p_F}{P}\right)^{1-\mu} \tag{18}$$

[19] To be precise, $M = \frac{1}{2}\left(\frac{p_H}{P}\right)^{1-\mu} M + \frac{1}{2}\left(\frac{p_H^*}{P^*}\right)^{1-\mu} S M^*$. Using (11) and the fact that $P = P^*$ and $p_H^* = p_F$ as a result of symmetry, (17) follows.

From (11), this is a positive function of $p_H/p_F = p_H/p_H^*$. Hence, results about prices give direct results about trade. Under a fixed exchange rate regime, where $M = M^*$, it is easily verified from (15) and (16) that $p_H = p_H^*$. In that case our measure of trade is equal to one. Because of symmetry in the model imports and exports are both half of GDP.

If $p_H^* > p_H$ under a float, trade is lower than under a fixed exchange rate regime, while the opposite is true when $p_H^* < p_H$. When firms charge a higher ex-ante price to foreign customers ($p_H^* > p_H$), the level of trade is reduced below one.[20] This happens when the foreign market is riskier than the domestic market under a float or, more precisely, when at $p_H = p_H^*$ the certainty equivalent of profits from marginal sales is lower in the foreign market than the domestic market.

To determine prices fully we need to substitute for the endogenous variables w and S in equations (15) and (16). Using (9) and (17), equilibrium prices are

$$p_H = \frac{\mu}{\mu - 1} P \frac{E\ u_l M}{E\ u_c M} \tag{19}$$

$$p_H^* = \frac{\mu}{\mu - 1} P \frac{E\ u_l M^*}{E\ u_c M} \tag{20}$$

It is easily seen that trade is reduced under a floating exchange rate system ($p_H^* > p_H$) when $E\ u_l M < E\ u_l M^*$. Based on this condition, in Appendix A we prove the following Proposition.

Proposition 1 *In the benchmark monetary model, trade is the same under a flexible as under a fixed exchange rate regime when utility is separable in consumption and leisure. Trade is higher (lower) under a flexible than under a fixed exchange rate system when consumption and leisure are complements (substitutes).*

The intuition behind this proposition can be found by realizing that in both markets the price can be written as

$$price = markup \cdot \frac{certainty\ equivalent\ costs}{certainty\ equivalent\ sales} \tag{21}$$

[20] We say that there is ex-ante price discrimination when the expected log of the price, measured in one currency, differs across markets. This happens when $log(p_H) \neq E\ log(Sp_H^*)$. Since $E\ log(S) = 0$, this is the case when $p_H \neq p_H^*$. It is appropriate to do this in logs because in levels it is possible that in Home currency $p_H < E(Sp_H^*)$, while in Foreign currency $E(p_H/S) > p_H^*$. This happens for example when $p_H = p_H^*$. The reason is that $E(S) = E(1/S) > 1$ due to symmetry and Jensen's inequality $E(1/S) > 1/E(S)$.

where $markup = \mu/(1-\mu)$ is a constant. First consider sales. The value of sales, measured in the domestic currency, is proportional to respectively M and SM^* when selling in the domestic and foreign market. But these are equal because $S = M/M^*$. So from the point of view of sales it does not matter in which market the goods are sold. While this obviously depends on the simple form of the exchange rate equation, there is a more general message here: general equilibrium analysis plays a key role. If the foreign currency depreciates it may be considered bad news for a home country exporter when holding everything else constant. But everything else is not constant. The depreciation of foreign currency can be a result of either a foreign monetary expansion or a home monetary contraction. A Foreign monetary expansion raises demand for goods sold in the foreign market. This offsets the loss from the depreciation. A home monetary contraction implies that income from sales would also have dropped when selling in the home market. This has the same effect on the domestic currency value of sales as the depreciation of the foreign currency when selling abroad.

In a partial equilibrium analysis the results would have been very different. Sales at home would be deterministic, while the domestic currency value of sales abroad would depend on the volatile exchange rate. With risk-averse firms the certainty equivalent of sales would be lower in the foreign market.[21] This leads to a higher price and lower trade.

Now consider the numerator of (21), the certainty equivalent of labor costs. In a partial equilibrium framework this is completely irrelevant because labor costs are deterministic. In our general equilibrium model the monetary shocks that drive exchange rate fluctuations also lead to uncertainty about wages and the quantity of goods sold. Both of these affect total labor costs, which is proportional to respectively wM and wM^* when selling in the home and foreign market. Two factors play a role here. First, under separable preferences and a float the wage rate is more correlated with domestic demand than foreign demand.[22] This makes it unattractive to sell goods in the home market: exactly when firms need to hire a lot of labor, wages are high. By itself it would lead to a higher price charged

[21] In the partial equilibrium literature it is generally assumed that firms maximize the expected value of a concave function of profits.

[22] Measured at $p_H = p_H^*$ the derivative of $w = u_l/u_c$ with respect to M is higher than the derivative with respect to M^* because consumption is proportional to M, while $\partial l/\partial M = \partial l/\partial M^*$.

in the domestic market, and therefore more trade under a floating exchange rate regime. On the other hand, labor costs in the domestic market are high exactly when firms can well afford to pay it: sales are high as well.[23] When selling in the foreign market it is possible that labor costs are high when sales are low, which happens when there is a domestic monetary contraction combined with a foreign monetary expansion.[24] This by itself makes it more attractive to sell goods in the home market in a floating exchange rate system. It would lead to a higher price charged in the foreign market, and therefore lower trade under a float.

When utility is separable in consumption and leisure these two effects cancel out, and trade is the same under floating and fixed exchange rate regimes. When consumption and leisure are complements, the wage rate is even more correlated with domestic demand for goods. In that case the first factor dominates, and trade is higher in a floating exchange rate system. When consumption and leisure are substitutes, the wage rate is less correlated with domestic demand for goods. In that case the second factor dominates, and trade is lower under a float.

We have already stressed that the results depend critically on the first of our two key model ingredients, a general equilibrium framework. It is not hard to show that the findings also depend critically on our second key model ingredient, deviations from PPP. In order to see that, consider what happens in the absence of pricing to market. When the same prices are charged to domestic and foreign customers the real exchange rate is constant. We continue to assume that prices are set in advance, but now in the seller's currency. This is the set of assumptions made by Obstfeld and Rogoff (1995, 1998) and Corsetti and Pesenti (1997). Let p_H be the price in domestic currency that domestic firms charge to both Home and Foreign consumers. Similarly, let p_F be the price in foreign currency that foreign firms charge to both Home and Foreign consumers. We show in Appendix B that

$$Trade = \frac{exports + imports}{GDP} = 1 - \frac{1}{2}\left(\frac{p_H}{P}\right)^{1-\mu} + \frac{1}{2}\left(\frac{p_H}{P^*}\right)^{1-\mu} \tag{22}$$

This measure of trade is now stochastic because the consumer price index is

[23] More formally, the weights u_c are lower in high M states of the world. This lowers the certainty equivalent of labor costs.

[24] More formally, it is possible that the weight u_c is high when M^* is high. This happens when M is low (so u_c is high). It raises the certainty equivalent of labor costs.

stochastic:

$$P = \left(\frac{1}{2}p_H^{1-\mu} + \frac{1}{2}(Sp_F)^{1-\mu}\right)^{1/(1-\mu)}$$

The important point though is that the exchange rate system has no effect on the expected level of trade, which is one under both exchange rate regimes. The reason is that there is no ex-ante price discrimination. We would obtain the same conclusion if prices were set ex-post, after the money shocks are observed.

3.3 International Trade in Assets

So far we have assumed that there are no internationally traded assets. In this section we will assume that residents of both countries trade assets before uncertainty about the money supplies is resolved. We do not need to concern ourselves with the exact number of assets and the precise payoff functions of individual assets. Because the assets are in zero net supply, the payoffs are merely a reallocation of resources between the two countries. All that matters in what follows is the total net payoff on the sum of all assets held, which we call θ in home currency for Home residents and θ^* in foreign currency for Foreign residents. It follows that $\theta + S\theta^* = 0$, and therefore $\theta^* = -\theta/S$. Total income after asset trade is $\tilde{Y} = M + \theta$ in the home country and $\tilde{Y}^* = M^* + \theta^*$ in the foreign country. Since domestic and foreign consumers can buy claims on respectively θ and θ^* at zero cost, the first order conditions are

$$E\, u_c \theta = 0 \tag{23}$$

$$E\, u_{c^*} \theta^* = 0 \tag{24}$$

Using these two first order conditions, and the money market equilibrium condition, we prove the following two Propositions in Appendix C.[25]

Proposition 2 *Under no asset market structure is consumption equal across countries ($c = c^*$) for all states of the world.*

[25] One caveat to Proposition 3 applies. Because $S = M/M^*$ generally does not hold anymore with trade in assets, our measure of trade (exports plus imports, divided by GDP) is actually stochastic. It is $0.5(p_F/P)^{1-\mu}(1 + \frac{M^*S}{M})$. But one can show that the ratio of expected exports plus imports to expected GDP is still $(p_F/P)^{1-\mu}$. With this slightly revised trade measure Proposition 3 applies.

Proposition 3 *Proposition 1 still holds once international trade in assets is introduced.*

Proposition 3 says that international trade in assets does not qualitatively change the effect of the exchange rate regime on trade. This may be surprising because one might think that under complete asset markets, in an Arrow Debreu world, all risks are shared and the exchange rate regime does not matter. But Proposition 2, which is used in the proof of Proposition 3, shows that equality of consumption across countries does not hold, even when asset markets are complete.[26]

The intuition behind Proposition 2 is closely related to deviations from PPP in the model. If consumers could physically ship goods across the two countries at no cost, the law of one price would hold and consumption would be equal across countries when financial markets are complete. It is optimal to engage in an agreement whereby each country consumes half of world output. But in our model there is goods market segmentation. Goods cannot be shipped at zero cost from one country to another. As shown by Apte, Sercu and Uppal (1997), Backus and Smith (1993), Betts and Devereux (1996b) and Kollmann (1995), under complete markets the ratio of the marginal utilities of consumption of two countries is proportional to the real exchange rate. This is intuitive because the real exchange rate is the appropriate marginal rate of transformation between consumption of the two countries. If Home country residents reduce their consumption by one unit, the value of this in terms of foreign currency is P/S. If this were transferred to foreign residents, their consumption would rise by $P/(SP^*)$. In our model the consumer price indices P and P^* are identical due to symmetry, so that the real exchange rate is $1/S$.

Consider a simple example. There is a monetary expansion in the home country. This is good news for home residents as their production and consumption rise. Under perfect risksharing one would expect home country residents to transfer half

[26] In real business cycles models with complete markets and non-separable preferences in consumption and leisure, consumption is not equal across countries because shocks to leisure affect the marginal utility from consumption. But that is not the explanation behind Proposition 2 in our model. First, Proposition 2 also holds under separable preferences. Second, $l = l^*$ if $c = c^*$ for all states of the world, so shocks to leisure affect the marginal utility of consumption identically in both countries.

of the increased wealth to the foreign country residents. The reason this will not happen is that the rate of exchange is unattractive. A drop in consumption by one unit in the home country raises consumption by $1/S$ in the foreign country. $1/S < 1$ because of the monetary expansion in the home country ($M > M^*$). The transfer of resources therefore lowers consumption globally.

Helpman (1981) shows in a deterministic model, and Lucas (1982) in a model with uncertainty and complete financial markets, that fixed and floating exchange rate systems lead to identical Pareto efficient outcomes. Helpman and Razin (1982) conjecture that this may not be the case once price rigidities are introduced, but do not study that friction. Following the formal introduction of price rigidities into general equilibrium open economy models by Obstfeld and Rogoff (1995), we are now in a position to study the implications of this friction. Proposition 3 shows that Helpman and Razin's conjecture was correct: in general the level of trade is affected by the exchange rate system, even when financial markets are complete.[27]

Forward or future contracts on foreign exchange represent an important example of internationally traded assets. Thus, Propositions 2 and 3 hold for this case as well. The forward exchange rate will be equal to one due to symmetry of the model. If households (or firms) sell forward b units of foreign currency, the net payoff from the forward position is $b(1 - S)$. It is the value of θ for this particular asset market structure.

The fact that risk cannot be completely hedged with a forward market is quite different from what is found in the partial equilibrium literature. If p^* is the pre-set foreign currency price of exports, profits of an exporting firm that sells forward b units of foreign currency are $Sp^*c^* - wc^* + b(1 - S)$. In the partial equilibrium literature it is generally assumed that S is the only source of uncertainty.[28] In

[27] Helpman and Razin (1982) were particularly interested in welfare. In this paper we have chosen to focus only on the effect of the exchange rate system on trade and capital flows, leaving the important welfare question for future research. We restrict ourselves to saying that in the context of the static model discussed in this section, and assuming separable preferences, the floating exchange rate system leads to higher welfare. This is because domestic and foreign demand shocks are perfectly correlated under a fixed exchange rate system, leading to larger volatility of leisure than under a float. Price rigidities play a key role in that result. Neumeyer (1998) finds that welfare can be higher under a fixed exchange rate regime when the variance of the money supplies is larger under a float. Here we have assumed the same variance of money supplies across exchange rate regimes.

[28] It is more this auxiliary assumption than the partial equilibrium nature of the analysis that

that case all exchange rate risk can be hedged by setting $b = p^*c^*$. In our general equilibrium model foreign demand c^* is itself stochastic, so that such a perfect hedge is impossible. From the point of view of households, if they (or firms) sell forward b units of foreign exchange, their income would be $M + b(1 - S)$. This can never be deterministic, no matter the level of b.

The sign of b can be both positive and negative. Although selling foreign currency forward reduces income uncertainty, the expected payoff from engaging in such a contract is negative. This is related to Siegel's paradox. From symmetry $E\ S = E\ \frac{1}{S}$. Since $E\ \frac{1}{S} > \frac{1}{E\ S}$, it follows that $E\ S > 1$. The expected payoff from selling one unit of foreign exchange forward, $E(1 - S)$, is therefore negative. Consider the case of separable and iso-elastic preferences. In that case $u_c = c^{-\gamma}$, where γ is the rate of relative risk-aversion. Appendix D shows that the first order condition with respect to b,

$$E\ u_c(1 - S) = 0 \tag{25}$$

implies that b depends on the rate of relative risk-aversion. When the rate of relative risk-aversion is one, $b = 0$. When it is larger (smaller) than one, b is positive (negative). For sufficiently high rates of risk-aversion the desire to hedge dominates. For very small rates of risk-aversion the positive expected payoff on buying foreign exchange forward dominates.

Although Proposition 3 implies that introducing a forward market has no qualitative effect on the level of trade in fixed versus floating exchange rate regimes, it has a quantitative effect. While it is hard to find closed form analytical solutions, numerical analysis shows that when agents sell foreign exchange forward ($b > 0$) the difference between trade in fixed and floating exchange rate regimes is smaller. The difference is exacerbated when $b < 0$. In other words, when financial markets are used to reduce income uncertainty the difference between the exchange rate systems (with regards to prices and trade) diminishes. Of course, this is only relevant when there is a difference between the two exchange rate systems in the first place, which happens when utility is non-separable in consumption and leisure.

We finish this sub-section with a couple of comments about trade in equity. So far we have assumed that traded assets only provide claims on given state-contingent payoffs. The analysis becomes more complicated once we introduce

matters here.

trade in equity. A share of a firm not only provides a claim on the future dividends of the firm, but also gives the owner a vote in the decision making process. By letting u_c be the weight attached to state contingent profits of domestic firms, so far we have assumed that only domestic residents make production decisions of domestic firms. This will be different once we allow for trade in equity, in which case foreign owners can take part in the decision making process. Proposition 3 still goes through when financial markets are complete. The marginal utility from additional income, measured in the domestic currency, is u_c/P for domestic consumers and $u_{c^*}/(SP^*)$ for foreign consumers. As discussed above, these weights are proportional when markets are complete.[29] Since home and foreign residents give the same relative weights to different states of the world, it is still correct to weigh firm profits by the marginal utility of consumption by domestic residents. This is generally not the case when markets are incomplete. Magill and Quinzii (1996) describe the difficulties in determining optimal production decisions under incomplete markets. The problem is that agents will generally attach different relative weights to different states of the world, so that they are not in full agreement on optimal decisions. Magill and Quinzii argue that under certain conditions it can be shown that the appropriate weight attached to future profits is a weighted average of the marginal utility of income of existing shareholders.[30] If before allowing for trade in equity all shares were owned by domestic residents, it is still appropriate to use u_c to weigh future profits. If the ownership is already spread among domestic and foreign shareholders, future profits need to be weighed by $\alpha u_c + (1-\alpha)u_{c^*}/S$, where α is the fraction owned by domestic shareholders. This substantially complicates optimal pricing decisions and in general Proposition 3 may no longer hold.

3.4 Other Sources of Uncertainty

In this section we extend the model to include productivity and government spending shocks. We assume that preferences are separable in consumption and leisure, so that trade is the same under the two exchange rate regimes when there are only

[29] This reflects the fact that all agents face the same Arrow-Debreu state contingent prices.

[30] One of these conditions is to allow for transfer payments among the owners of the firm. This may not be practical with many small shareholders.

monetary shocks.

Governments buy domestically produced public goods and pay with the domestic currency. Utility from public goods is separable from private consumption and leisure. Domestic and foreign nominal government spending, respectively G and G^* (in local currencies), are random and paid for by lump sum taxes. Production of one public good requires one unit of labor. Production of private goods requires $1/a$ units of labor at home and $1/a^*$ abroad. These productivity parameters are stochastic. Profits of domestic firms producing for the private sector are $\Pi = p_H(i)c(i) + Sp_H^*(i)c^*(i) - w(c(i) + c^*(i))/a$. Firms maximize the certainty equivalent of profits, subject to the demand equations $c(i) = \frac{1}{2}\left(\frac{p_H(i)}{P}\right)^{-\mu}\frac{M-G}{P}$, and $c^*(i) = \frac{1}{2}\left(\frac{p_H^*(i)}{P^*}\right)^{-\mu}\frac{M^*-G^*}{P^*}$. Optimal prices are

$$p_H(i) = \frac{\mu}{\mu - 1}\frac{E\ u_c(w/a)(M-G)}{E\ u_c(M-G)} \tag{26}$$

$$p_H^*(i) = \frac{\mu}{\mu - 1}\frac{E\ u_c(w/a)(M^*-G^*)}{E\ u_cS(M^*-G^*)} \tag{27}$$

From the money market equilibrium equation $M = p_Hc_H + Sp_H^*c_H^* + G$, we can solve for the exchange rate as:

$$S = \frac{M-G}{M^*-G^*} \tag{28}$$

An increase in domestic government spending leads to an appreciation because it leads to a rise in the demand for domestic goods (and money) and a drop in demand for foreign goods (and money).

With this equilibrium exchange rate the denominators in the price equations are again identical. The level of sales is still the same in both markets. An increase in G^* reduces private consumption demand abroad, but it also leads to an appreciation of the foreign currency. These two effects offset each other, leaving the domestic currency value of sales abroad unaffected. An increase in G leads to a depreciation of the foreign currency. But the loss in the domestic currency value from foreign sales is exactly equal to the loss in sales in the home market.

It follows that the sign of $p_H - p_H^*$ is equal to the sign of $E\ u_c(w/a)[(M - G) - (M^* - G^*)]$. In other words, the price differential depends on the certainty equivalent of labor costs in the home market relative to that in the foreign market. Under a fixed exchange rate regime $M - G = M^* - G^*$, so that the two prices are again equal, and the measure of trade is one.[31] If under a float the degree of freedom in monetary and fiscal policy is used to lower the certainty equivalent of labor costs in the domestic market, then $p_H < p_H^*$ and trade is lower under a floating exchange rate regime. This will be the case if the degree of freedom in policy under a float is used to exert a stabilizing role in the home market, by reducing the volatility of labor costs associated with domestic sales. This can be done either by reducing the volatility of labor demand associated with domestic sales, or by reducing the correlation between the wage rate and labor demand. We will now give examples of these two types of policies.

The first example is one with only monetary and technology shocks. Government spending is zero. Consider an accommodative policy under a floating exchange rate regime. The central bank fully accommodates technology shocks, so that M/a is a constant. Therefore labor demand associated with domestic sales is constant. Labor demand associated with foreign sales, M^*/a, is still volatile. This makes it more attractive to sell goods in the home market, which reduces trade. Under a fixed exchange rate regime monetary authorities do not have the degree of freedom to accommodate technology shocks because equal money supplies are necessary to keep the exchange rate constant at one. It is easily verified, with a proof similar to that in Appendix A, that in this example trade is indeed lower under a floating exchange rate regime.

In the second example we assume that there are only government spending shocks. The money supply is constant and identical in both countries, and $a = a^* = 1$. Domestic government spending shocks reduce the correlation between the wage rate and labor demand associated with domestic sales. A decline in government spending lowers the wage rate at home because of the lower demand for labor.[32] At the same time it raises private domestic demand because of the lower taxes. Therefore demand for labor associated with domestic private sector sales tends to be high when the wage rate is low. This reduces the volatility of total labor costs associated with domestic sales, making it more attractive to sell in the home market. Using a proof similar to that in Appendix A, it is again easily verified that trade is lower under a floating exchange rate regime in this

[31] The definition of trade is now exports plus imports, divided by production of private sector goods.

[32] As with the private goods, it is assumed that prices of public goods are set in advance.

case. Under a fixed exchange rate $G = G^*$, so both markets are equally attractive.

To summarize, when the degree of freedom under a float is used to exert a stabilizing role in the home market, by reducing the volatility of total labor costs associated with domestic sales, with separable preferences the level of trade is lower under a float.

4 A Two-Period Model

In order to study net capital flows we need to extend the model to multiple periods. In principle one may want to extend to an infinite horizon framework. But it is well known that infinite horizon stochastic general equilibrium models with incomplete markets are not analytically tractable. We therefore only consider a two period version of the model. This allows us to explicitly identify at an analytical level what factors distinguish fixed and floating exchange rate regimes with respect to the size of net capital flows. These same factors are likely to play a role in models with more than two periods.

4.1 Extending the Benchmark Model

To keep matters as simple as possible, we examine the case where there is only uncertainty about money supplies in the second period. Moreover, we assume that the utility function is separable in consumption and leisure:

$$u(c_1) + v(l_1) + \beta Eu(c) + \beta Ev(l) \tag{29}$$

where β is the time discount factor and subscript 1 refers to period 1. To simplify notation, we drop the subscript for second period variables. In the symmetric equilibrium there is no net borrowing or lending among countries and the solution in the second period is similar to the one-period case studied in the previous section. In particular, there is no ex-ante price discrimination as utility is separable (i.e., Proposition 1 applies). In order to induce net capital flows we have to introduce an asymmetry. We assume that domestic residents have a higher time discount rate. This raises their saving and leads to a net capital outflow from the home country to the foreign country.

Because of this asymmetry all four second period prices (p_H, p_F, p_H^*, p_F^*) are generally different, even with a separable utility function. A full solution of the model can only be solved numerically. To get an analytical understanding, however, we examine the model by assuming that prices are set *before* it becomes clear that the β's are different. In other words, the increase in the home country's β comes as a complete surprise to firms, or they attach a negligible weight to this possibility when setting prices. When prices are set under the assumption of equal β's, all four prices will be identical, as was the case in the previous section under separability. We are then able to obtain explicit analytical results. In order to verify that our findings are not sensitive to the price-setting assumption, we have solved numerically for the case where prices are set *after* it becomes clear that the β's are different, but before second period uncertainty is resolved. This has no qualitative effect on the results.

It is well known that when financial markets are complete, there is no need for trade in assets after some initial date. In the present context complete asset markets would imply that there is trade in claims associated with the uncertainty about β. If the home country gets a high β draw, the payoff on the assets is such that the home country makes a net transfer to the foreign country in period 1 and receives a net transfer in period 2. These transfers are not capital flows. They are asset returns. Such a setup is not very interesting if our aim is to understand capital flows.

Assume therefore that there is no trade in claims associated with the uncertainty about β, for example because this preference shock is not observable by the other country. Financial markets can then still be complete in a more narrow sense: there is trade in claims on all states of the world in period 2. We saw in the previous section that such market completeness does not lead countries to equally share risk associated with global output. The same is true in this section. We will consider trade in only two assets: domestic and foreign currency nominal bonds. Although generally this means that financial markets are incomplete, with two states of the world two traded assets are sufficient for complete spanning. Since our findings do not depend on the number of states of the world, it again does not matter whether asset markets are complete or not. The asset market structure does not play a crucial role, at least qualitatively. However, it is useful to focus on trade in nominal bonds as it makes the analysis more transparent and trade in nominal assets is empirically the most relevant.

The bonds have a price of one in local currency in period 1, and a nominal payoff of respectively R and R^* of local currency in period 2. Domestic residents buy b_H domestic bonds and b_F foreign bonds. Their budget constraints are:

$$P_1 c_1 = Y_1 - b_H - S_1 b_F \tag{30}$$

$$Pc = Y + Rb_H + SR^* b_F \tag{31}$$

Similarly, for foreign country residents:

$$P_1 c_1^* = Y_1^* - \frac{1}{S_1} b_H^* - b_F^* \tag{32}$$

$$Pc^* = Y^* + \frac{1}{S} Rb_H^* + R^* b_F^* \tag{33}$$

Consumer demand by domestic residents is still as in (10), with Y replaced by $Y_1 - b_H - S_1 b_F$ in period 1, and $Y + Rb_H + SR^* b_F$ in period 2. After substituting consumer demand equations into the second period money market equilibrium condition $M = Y = p_H c_H + Sp_H^* c_H^*$, we still obtain

$$S = \frac{M}{M^*}$$

With money supplies equal in period 1, $S_1 = 1$.

It is useful to define real interest rates as $r = R\frac{P_1}{P}$ and $r^* = R^* \frac{P_1}{P}$. The first order conditions for domestic residents are then:

$$r = \frac{u'(c_1)}{\beta E u'(c)} \tag{34}$$

$$r = r^* \frac{Eu'(c)S}{Eu'(c)} \tag{35}$$

Equation (34) is the standard consumption Euler equation, equating the real interest rate to the expected marginal utility of consumption in the first relative to the second period. It determines the intertemporal consumption allocation and thus saving. Equation (35) is a real interest parity condition. It equates the real interest rate on domestic bonds to the risk-adjusted real return on foreign bonds. For given interest rates it can also be considered a portfolio allocation condition. In general a real interest rate differential across countries can be the result of an expected change in the real exchange rate or a currency risk premium. In our model it can only be the result of a currency risk premium because the expected real depreciation is zero.[33]

Similar first order conditions apply to foreign country residents:

$$r^* = \frac{u'(c_1^*)}{\beta E u'(c^*)} \tag{36}$$

$$r^* = r \frac{E u'(c^*) \frac{1}{S}}{E u'(c^*)} \tag{37}$$

Finally, bond market equilibrium conditions are

$$b_H + b_H^* = 0 \tag{38}$$

$$b_F + b_F^* = 0 \tag{39}$$

The model is summarized by the six equations (34)-(39), which can be used to solve for r, r^*, b_H, b_F, b_H^*, b_F^*. Net capital flows are simply $KA = b_H + b_F$.

4.2 Net Capital Flows

Even for specific forms of the utility function there is no closed form solution to this system of equations. We therefore consider the effect on net capital flows of a marginal change in the domestic country's time discount rate β. Numerical solutions show that the results are qualitatively the same for large changes in β.

The solution can be found by fully differentiating the system of equations (34)-(39) around the symmetric equilibrium where the domestic and foreign time discount rates are equal.[34] Details are given in Appendix E. By differentiating the intertemporal allocation equations (34) and (36) we find:

$$dKA = \Omega_1 d\beta + \Omega_2 (dr - dr^*) \tag{40}$$

where the parameters Ω_1 and Ω_2 are defined in the Appendix. Ω_1 is positive. It is equal to half of $\partial Saving/\partial\beta$, which is the response of domestic saving when the time discount rate increases, holding interest rates constant and assuming $db_H = db_F$. When domestic and foreign interest rates are equal, as in deterministic

[33] $E\ \Delta ln(S) = 0$, while national inflation rates are identical.

[34] Bacchetta and van Wincoop (1997) use a similar approach.

current account models, the increase in domestic saving leads to a decline in the world interest rate. The lower interest rate reduces the equilibrium net capital outflow to half of $\partial Saving/\partial\beta$.

In contrast to deterministic current account models, the interest differential will now generally be different from zero. Ω_2 measures the sensitivity of net capital flows to an increase in the interest rate differential $r - r^*$. This is a result of changes in domestic and foreign saving due to substitution and income effects. The substitution effect is always positive; it leads to higher domestic relative to foreign saving when the domestic interest rate rises relative to the foreign interest rate. Dependent on whether individuals are lending or borrowing in domestic currency, the income effect can be positive or negative.[35] Under iso-elastic preferences the income effect is zero with log-utility, so that $\Omega_2 > 0$. Since the substitution effect is likely to dominate in practice, we will assume that $\Omega_2 > 0$ in what follows.[36]

By differentiating the portfolio allocation equations (35) and (37) we find (see Appendix E):

$$dr - dr^* = \Omega_3 dKA \tag{41}$$

The parameter Ω_3 measures the change in the risk-premium in response to a net capital outflow of one. If $\Omega_3 < 0$, we say that domestic residents have a preference for domestic assets. If this is the case, an increase in their saving will lead to an increase in demand for domestic relative to foreign bonds and therefore a decline in the domestic relative to the foreign interest rate. We show in Appendix F that with iso-elastic preferences $u(c) = c^{1-\gamma}/(1-\gamma)$ agents have a preference for domestic bonds ($\Omega_3 < 0$) when the rate of relative risk aversion γ is larger than one. Ω_3 is zero for log-utility and positive when $\gamma < 1$.[37] Since the rate of relative risk-aversion is generally found to be larger than one, we will assume that $\Omega_3 < 0$ in most of what follows.

[35] For example, when $b_H > 0$ an increase in $r - r^*$ raises second period income in the home country, which lowers first period saving.

[36] As can be seen from the expression of Ω_2 in Appendix E, only for very high levels of b_H could the income effect dominate.

[37] For $\gamma \neq 1$ we can only prove these assertions about the sign of Ω_3 for two and three states of the world, but numerically we find it to hold for any number of states. The reason why agents may have a preference for foreign bonds with regards to marginal changes in asset positions (when $\gamma < 1$) is that an increase in domestic bond holdings reduces uncertainty about consumption changes (see (31)), which reduces the risk-premium on foreign bonds.

Combining (40) and (41), the change in net capital flows KA is equal to

$$dKA = \frac{\Omega_1 d\beta}{1 - \Omega_2 \Omega_3} \tag{42}$$

The intuition behind this equation becomes clear in Figure 1, which graphically illustrates the equilibrium. The upward sloping line, referred to as "intertemporal allocation", represents equation (40). The slope is given by Ω_2. The downward sloping line, referred to as "portfolio allocation", represents equation (41). Its slope is given by Ω_3.

The increase in the domestic time discount rate leads to an upward shift in the "intertemporal allocation" line. The extent of this shift is given by $\Omega_1 d\beta$. When the interest differential is held constant, the net capital outflow is measured by KA_1. But at an unchanged interest differential the demand for domestic bonds is larger than the demand for foreign bonds as domestic agents prefer to allocate their increased saving to domestic bonds. The interest differential $r - r^*$ falls until an equilibrium is reached at point A. The lower interest differential leads to a decline in domestic minus foreign saving, reducing the net capital outflow to KA_2. The stronger the preference for domestic bonds, the smaller the equilibrium net capital outflow. In the extreme case of "infinite" preference for domestic bonds, the equilibrium would be at point C and net capital flows are zero. This is the standard closed economy result, where the domestic interest rate decreases enough to reduce the desired increase in domestic saving to zero.

We now turn to a comparison of fixed and floating exchange rate systems. There are two differences between the exchange rate systems. First, the response of saving to an increase in the time discount rate, as captured by the upward shift in the intertemporal allocation line in Figure 1 ($\Omega_1 d\beta$), is different under a fixed exchange rate system. Whether it is larger or smaller depends on several factors, including the third order derivative of the utility function. For log-utility Ω_1 is larger under a float, leading to larger net capital flows than under a fixed exchange rate system. But the more interesting difference between the two systems is associated with asset preference. Under a fixed exchange rate system there is only one interest rate, so that $\Omega_3 = 0$. Graphically, the intertemporal allocation line is vertical at $dr - dr^* = 0$. This by itself leads to larger net capital flows under a fixed exchange rate system. The preference for domestic assets under a float leads to a risk-premium on foreign bonds, which reduces the real interest rate at home relative to the real interest rate abroad, and dampens the net capital outflow.[38]

The general equilibrium framework again plays a key role. In a partial equilibrium setup interest rates would be fixed. There would be no relationship between the size of the currency risk-premium and the level of net capital flows. The second key model ingredient, deviations from PPP, also plays an important role. In the context of a two-country monetary general equilibrium model with PPP, Bacchetta and van Wincoop (1997) find that there is no currency risk premium, even when there are net capital flows.

5 Conclusion

We have developed a simple analytical framework to study the effect of the exchange rate regime on trade and capital flows. Two key model ingredients play a central role: a general equilibrium framework and deviations from PPP. We can summarize our findings as follows. First, with only monetary shocks, and utility that is separable in consumption and leisure, the level of trade is unaffected by the exchange rate regime. Second, when adding fiscal and technology shocks we find that trade is lower under a float when macroeconomic policy is used to exert a stabilizing role in the home market. Third, the level of net capital flows tends to be lower under a floating exchange rate regime when there is a preference for domestic bonds, which happens when the rate of risk-aversion is larger than one. Fourth, these findings are not qualitatively affected by the international asset market structure.

The finding that trade is unaffected by the exchange rate regime in the benchmark monetary model (with separable preferences) is consistent with conclusions that have been drawn from the extensive empirical literature. Moreover, the model's predictions regarding net capital flows are in line with the high correlation between domestic saving and investment rates (Feldstein and Horioka, 1980). There is some very preliminary evidence that net capital flows may indeed be neg-

[38] Note that in the unlikely case where there is a preference for foreign bonds ($\gamma < 1$), the portfolio allocation line would be upward sloping. In that case the domestic real interest rate will be larger than the foreign real interest rate under a float, leading to a further rise in domestic relative to foreign saving and larger net capital flows than under a fixed exchange rate system.

atively affected by exchange rate volatility, but more careful work needs to be done to verify that.[39]

We regard the model as only a starting point towards understanding the implications of the exchange rate regime for trade and capital flows. We have purposefully kept the model as simple as possible. It can be extended in many ways. One of the more obvious extensions is to consider an infinite horizon framework, including also capital formation. Although this extension is technically challenging, it is likely to be important as the exchange rate will be affected by expectations associated with *future* fundamentals. We have also abstracted from the location choice of firms. As a result of exchange rate uncertainty firms may decide to locate production in the foreign market. Entry and exit decisions could be built into the model and FDI could be analyzed. We have assumed that trade is a result of monopolistic competition in differentiated goods. One may also want to consider trade as a result of different factor endowments. We can of course add many more possible extensions to this list, all of which will add more meat to the bones and provide further insights.

Another important objective of future research is to evaluate welfare implications of different exchange rate systems. Mundell's (1961) concept of an optimum currency area relies fundamentally on nominal rigidities. So far efforts to study welfare implications of exchange rate regimes in a general equilibrium framework have been conducted under the maintained hypothesis of purchasing power parity. The model developed in this paper, in which price rigidities play a central role, can provide a good starting point for revisiting the welfare question.

[39] Bacchetta and van Wincoop (1997) find that net capital flows tend to be lower under more flexible exchange rate regimes. Bayoumi (1990) shows that net capital flows are smaller during the recent floating exchange rate period than during the gold standard. Iwamoto and van Wincoop (1998) find that net capital flows are smaller across countries than across regions within a country, which use the same money. But none of these results control for a large number of other factors that may affect the size of capital flows.

Appendix A: Proposition 1

To prove Proposition 1, we apply a useful result stated in Lemma 1:

Lemma 1 *Let $f(M, M^*)$ be a continuous differentiable function, and assume a symmetric distribution for M and M^*. Then $E\ f(M, M^*)(M - M^*) < (>)(=)0$ when $\frac{\partial f}{\partial M} < (>)(=)\frac{\partial f}{\partial M^*}$ $\forall M, M^*$ in the range (M^{min},M^{max}).*

Here M^{min} and M^{max} are the lowest and highest possible values of the money supplies.

Proof Lemma 1

$$E\ f(M, M^*)(M - M^*) = \sum_{z=1}^{Z} v(z) f(M, M^*)(M(z) - M^*(z)) \tag{43}$$

Consider a specific state z_1. The symmetry assumption implies that there is a state z_2 (which may be the same state), so that $v(z_1) = v(z_2)$, $M(z_1) = M^*(z_2)$, and $M(z_2) = M^*(z_1)$. If $z_1 = z_2$, this state does not affect the summation in (43). Now assume $\frac{\partial f}{\partial M} < \frac{\partial f}{\partial M^*}$ $\forall M, M^* \in [M^{min}, M^{max}]$ and $z_1 \neq z_2$. We will show that in that case the sum of the two terms in the summation of (43) associated with states z_1 and z_2, $\Theta(z_1, z_2)$, is negative when $M(z_1) \neq M(z_2)$. Since this is true for any couple (z_1, z_2), it follows that $E\ f(M, M^*)(M - M^*) < 0$. We have $\Theta(z_1, z_2) \equiv v(z_1)[M(z_1) - M^*(z_1)][f(M(z_1), M(z_2)) - f(M(z_2), M(z_1))]$. Assume, without loss of generality, that $M(z_1) > M(z_2)$. From the assumption on $f(M, M^*)$, $f(M(z_1), M(z_2)) < f(M(z_2), M(z_1))$, which implies that $\Theta < 0$. The proof is analogous under the assumption that $\frac{\partial f}{\partial M}$ is larger than (or equal to) $\frac{\partial f}{\partial M^*}$ $\forall M, M^* \in [M^{min}, M^{max}]$.

Proof Proposition 1

From (15) and (20), trade is lower when $E\ u_l(M - M^*) < 0$. We can apply Lemma 1, using $f(M, M^*) = u_l$, $c = \frac{M}{P}$, $l = 1 - \frac{1}{2}(p_H/P)^{-\mu} M/P - \frac{1}{2}(p_H^*/P)^{-\mu} M^*/P$. It follows that

$$\frac{\partial f}{\partial M} - \frac{\partial f}{\partial M^*} = \frac{1}{P} u_{cl} + \frac{1}{2}\frac{1}{P} u_{ll}[(p_H^*/P)^{-\mu} - (p_H/P)^{-\mu}] \tag{44}$$

When utility is separable in consumption and leisure, $p_H = p_H^*$ follows by contradiction. If $p_H^* > p_H$, $\frac{\partial f}{\partial M} - \frac{\partial f}{\partial M^*} > 0$ because $u_{ll} < 0$. Lemma 1 then tells us that $E\ u_l(M - M^*) > 0$. From (19) and (20) it follows that $p_H > p_H^*$, establishing a contradiction. We find a contradiction in a similar way when assuming $p_H^* > p_H$. The two prices must therefore be equal.

When consumption and leisure are complements ($u_{cl} > 0$), we prove that $p_H > p_H^*$ by contradiction. When $p_H \leq p_H^*$, $\frac{\partial f}{\partial M} - \frac{\partial f}{\partial M^*} > 0$ from (44). From Lemma 1, (19), and (20) it follows that $p_H > p_H^*$, establishing a contradiction. When consumption and leisure are substitutes ($u_{cl} < 0$), $p_H < p_H^*$ follows similarly by contradiction.

Appendix B: One period model with purchasing power parity

Assume domestic firms set a price p_H in domestic currency and foreign firms set a price p_F in foreign currency. The same price is charged to customers of both markets. Demand for domestic firms by Home and Foreign consumers is, respectively, $c_H = 0.5(p_H/P)^{-\mu}M/P$ and $c_H^* = 0.5[(p_H/S)/P^*]^{-\mu}M^*/P^*$. Substitution of these demand functions in the money market equilibrium equation $M = p_H c_H + p_H c_H^*$, and using that $SP^* = P$ (because the law of one price holds) yields

$$0.5(p_H/P)^{1-\mu}SM^* = [1 - 0.5(p_H/P)^{1-\mu}]M \tag{45}$$

The exchange rate is no longer simply equal to M/M^*.

The value of imports is $0.5(Sp_F/P)^{1-\mu}M$, while the value of exports is c_H^* (see above) times p_H. Using the fact that $p_H = p_F$ due to symmetry, and $SP^* = P$, we can write imports plus exports as $0.5(p_H/P^*)^{1-\mu}M + 0.5(p_H/P)^{1-\mu}SM^*$. Substituting (45), and dividing by GDP (M), our trade measure becomes $1 - 0.5(p_H/P)^{1-\mu} + 0.5(p_H/P^*)^{1-\mu}$.

Appendix C: Proof of Propositions 2 and 3

After introducing international trade in assets, M and M^* in the consumer demand equations are replaced by $\tilde{Y}$ and $\tilde{Y}^*$. As a result, the prices are still given by (15) and (16), with M replaced by $\tilde{Y}$, and M^* replaced by $\tilde{Y}^*$:

$$p_H(i) = \frac{\mu}{\mu - 1} P \frac{E\ u_c w \tilde{Y}}{E\ u_c \tilde{Y}} \tag{46}$$

$$p_H^*(i) = \frac{\mu}{\mu - 1} P \frac{E\ u_c w \tilde{Y}^*}{E\ u_c S \tilde{Y}^*} \tag{47}$$

It is still true that the certainty equivalent of sales, in the denominator, is the same in the two markets. This can be seen by combining the money market equilibrium condition with the first order condition (23) for asset holdings. The money market equilibrium condition is

$$M = Y = p_H c_H + S p_H^* c_H^* = \frac{1}{2}\left(\frac{p_H}{P}\right)^{1-\mu}\tilde{Y} + \frac{1}{2}S\left(\frac{p_H^*}{P}\right)^{1-\mu}\tilde{Y}^* \tag{48}$$

From the first order condition (23) for asset holdings it follows that $E\ u_c M = E\ u_c \tilde{Y}$. If we substitute this into the money market equilibrium condition, after multiplying by u_c and taking expectations, it follows that $E\ u_c\tilde{Y} = E\ u_c S\tilde{Y}^*$. So the certainty equivalent of sales is equal across markets.

Since $w = Pu_l/u_c$, the sign of $p_H - p_H^*$ depends on the sign of $E\ u_l(\tilde{Y} - \tilde{Y}^*)$. This is exactly the same as we found in the absence of trade in assets, with M and M^* replaced by $\tilde{Y}$ and $\tilde{Y}^*$. Moreover, consumption and leisure depend on $\tilde{Y}$ and $\tilde{Y}^*$ in the same way as they previously were functions of M and M^*. Since the two countries are ex-ante identical, the joint distribution of $\tilde{Y}$ and $\tilde{Y}^*$ is symmetric. We will now show that under no asset market structure will $\tilde{Y}$ and $\tilde{Y}^*$ be the same for all states of the world (Proposition 2). After having shown that, it is clear that the conditions leading to Proposition 1 still hold, which proves Proposition 3.

The proof of Proposition 2 is done by contradiction. Assume that $c = c^*$, and therefore $\tilde{Y} = \tilde{Y}^*$, for all states of the world. It then follows from the price equations that $p_H = p_H^*$ (we already knew the denominators were equal). Substituting this in the money market equilibrium condition, we have $S = M/M^*$. In that case $\tilde{Y} = \tilde{Y}^*$ implies $\theta = \frac{M(M^*-M)}{M+M^*}$ and $\theta^* = \frac{M^*(M-M^*)}{M+M^*}$. The foreign counterpart to first order condition (23) is $E\ u_{c^*}\theta^* = 0$. Since $c = c^*$, it follows that $u_c = u_{c^*}$ and therefore $E\ u_c(\theta + \theta^*) = 0$. But $E\ u_c(\theta+\theta^*) = -E\ u_c\frac{(M-M^*)^2}{M+M^*} < 0$. This establishes a contradiction, which proves Proposition 2.

Appendix D: Hedging with an iso-elastic utility function

Here we show that the forward market position or the asset position in the two-period model depends on the degree of risk aversion. In the one-period model, the forward position b is given by (25). This is also the level of b_H in the two-period symmetric model. Without loss of generality we normalize the price level to one so that $c = M + b(1-S)$. The marginal utility of consumption is $u'(c) = c^{-\gamma}$ where γ is the rate of relative risk aversion. Define $f(b) = Eu'(c)(1-S)$. Now evaluate f at $b = 0$: $f(0) = EM^{1-\gamma}(\frac{1}{M} - \frac{1}{M^*})$. Applying Lemma 1, one can easily show that $f(0) > (<)0$ if $\gamma > (<)1$. Since u is concave, $\partial f/\partial b < 0$. Hence, to have $f(b) = 0$, we need $b > (<)0$ when $\gamma > (<)1$.

Appendix E: Deriving equations (40) and (41)

First we differentiate totally equations (34) and (36) and evaluate them at the symmetric equilibrium to get

$$rd\beta + \beta dr = -(r^2\beta a_1 + a_0)db_H - (r^2\beta a_2 + a_0)db_F - r\beta b_H(a_1 dr - a_2 dr^*) \quad (49)$$

$$\beta dr^* = (r^2\beta a_2 + a_0)db_H + (r^2\beta a_1 + a_0)db_F + r\beta b_H(a_2 dr - a_1 dr^*) \quad (50)$$

where:

$$r^2(a_1 + a_2) + \frac{2}{\beta P_1}\frac{u''(c_1)}{Eu'(c)}$$

$$a_0 = \frac{1}{P_1}\frac{u''(c_1)}{Eu'(c)}$$

$$a_1 = \frac{1}{P_1}\frac{Eu''(c)}{Eu'(c)}$$

$$a_2 = \frac{1}{P_1}\frac{Eu''(c)S}{Eu'(c)} = \frac{1}{P_1}\frac{Eu''(c^*)\frac{1}{S}}{Eu'(c^*)}$$

Subtracting (50) from (49), we find (40) with

$$\Omega_1 = -\frac{r}{r^2\beta(a_1 + a_2) + 2a_0} = -r/\left(\frac{r^2\beta}{P_1}\frac{Eu''(c)(1+S)}{Eu'(c)} + \frac{2}{P_1}\frac{u''(c_1)}{Eu'(c)}\right)$$

and

$$\Omega_2 = \frac{\beta}{r}(1 + rb_H(a_1 + a_2))\Omega_1 = \Omega_1\frac{\beta}{r}\left(1 + \frac{rb_H}{P_1}\frac{Eu''(c)(1+S)}{Eu'(c)}\right)$$

To derive equation (41) we fully differentiate equations (35) and (37) and evaluate them at the symmetric equilibrium. We get:

$$dr - dr^* = -r^2(a_1 - a_2)db_H - r^2(a_2 - a_3)db_F - rb_H(a_1 - a_2)dr + rb_H(a_2 - a_3)dr^* \quad (51)$$

$$dr - dr^* = -r^2(a_2 - a_3)db_H - r^2(a_1 - a_2)db_F - rb_H(a_2 - a_3)dr + rb_H(a_1 - a_2)dr^* \quad (52)$$

where

$$a_3 = \frac{1}{P_1}\frac{Eu''(c)S^2}{Eu'(c)} = \frac{1}{P_1}\frac{Eu''(c^*)\frac{1}{S^2}}{Eu'(c^*)}$$

By adding these two equations we find (41) where

$$\Omega_3 = -\frac{r^2(a_1 - a_3)}{2 + rb_H(a_1 - a_3)} = -r/\left(2\frac{P_1}{r}\frac{EU'(c)}{Eu''(c)(1-S^2)} + b_H\right)$$

Appendix F: The sign of Ω_3

We have already shown in Appendix D that the sign of b_H is the same as the sign of $\gamma - 1$. First consider log-utility, in which case $\gamma = 1$ and $b_H = 0$. In that case $c = M/P$ and $Eu''(c)(1 - S^2) = E(1/M)^2 - E(1/M^*)^2 = 0$. It is easily verified from the expression for Ω_3 in Appendix E that $\Omega_3 = 0$ in this case. It remains to be shown that $\Omega_3 < 0$ if $\gamma > 1$ and $\Omega_3 > 0$ if $\gamma < 1$. We only provide the proof for two and three states of the world. Numerical analysis shows that it holds for any number of states.

First consider two states of the world. By symmetry $M(1) = M^*(2)$, $M(2) = M^*(1)$, and both states have equal probability. $Eu''(c)(1-S^2) = -0.5\gamma c(1)^{-\gamma-1}(1-S(1)^2) - 0.5\gamma c(2)^{-\gamma-1}(1 - S(2)^2)$. Substituting the first order condition $Eu'(c)(1-S) = 0$, which is written out as $0.5c(1)^{-\gamma}(1 - S(1)) + 0.5c(2)^{-\gamma}(1 - S(2)) = 0$, it follows that

$$Eu''(c)(1 - S^2) = \gamma c(2)^{-\gamma}(1 - S(2)) \left[\frac{1 + S(1)}{c(1)} - \frac{1 + S(2)}{c(2)}\right]$$

Assume without loss of generality that $M(1) > M(2)$. Therefore $1 - S(2) > 0$. Using $c(1) = M(1) + b_H(1 - \frac{M(1)}{M(2)})$ and $c(2) = M(2) + b_H(1 - \frac{M(2)}{M(1)})$, we can write

$$\frac{1 + S(1)}{c(1)} - \frac{1 + S(2)}{c(2)} = 2\frac{b_H}{c(1)c(2)}\left(\frac{M(1)}{M(2)} - \frac{M(2)}{M(1)}\right)$$

Since the sign of b_H is that of $\gamma - 1$, it follows that $Eu''(c)(1 - S^2) > 0(< 0)$ when $\gamma > 1(< 1)$. From the expression of Ω_3 in Appendix E it immediately follows that $\Omega_3 < 0(> 0)$ when $\gamma > 1(< 1)$. This proof easily extends to the case of three states. By symmetry M must be equal to M^* in the third state, so that $S = 1$ in that state and the expressions for $Eu'(c)(1 - S)$ and $Eu''(c)(1 - S^2)$ remain unaltered.

References

[1] Adam-Müller, A.F.A. (1997), "Export and Hedging Decisions under Revenue and Exchange Rate Risk: A Note", *European Economic Review* 41, 1421-1426.

[2] Apte, P., P. Sercu and R. Uppall (1997), "The Exchange Rate and Purchasing Power Parity in Arbitrage-Free Models of Asset Pricing", working paper, University of British Columbia.

[3] Bacchetta, P. and E. van Wincoop (1997), "Trade in Nominal Assets and Net International Capital Flows", CEPR Discussion Paper No. 1569.

[4] Backus, D. and G.W. Smith (1993), "Consumption and Real Exchange Rates in Dynamic Economies with Non-traded Goods", *Journal of International Economics* 35, 297-316.

[5] Baldwin, R. (1988), "Hysteresis in Import prices: The Beachhead Effect", *American Economic Review* 78, 773-785.

[6] Baron, D.P. (1976), "Flexible Exchange Rates, Forward Markets, and the Level of Trade", *American Economic Review* 66, 253-66.

[7] Baxter, M. and A.C. Stockman (1989), "Business Cycles and the Exchange-Rate System", *Journal of Monetary Economics* 23, 377-400.

[8] Bayoumi, T., 1990, "Saving-Investment Correlations: Immobile Capital, Government Policy or Endogenous Behaviour?", *IMF Staff Papers* 37, 360-387.

[9] Betts, C. and M. Devereux (1996a), "The Exchange Rate in a Model of Pricing-To-Market", *European Economic Review* 40, 1007-1021.

[10] Betts, C. and M. Devereux (1996b), "Exchange Rate Dynamics in a Model of Pricing-To-Market", mimeo.

[11] Betts, C. and M. Devereux (1997), "The International Monetary Transmission Mechanism: A Model of Real Exchange Rate Adjustment under Pricing-To-Market", mimeo.

[12] Chari, V.V., P.J. Kehoe, and E.R. McGrattan (1997), "Monetary Shocks and Real Exchange Rates in Sticky Price Models of International Business Cycles", NBER Working Paper No. 5876.

[13] Clarida, R. and J. Gali (1994), "Sources of Real Exchange Rate Fluctuations: How Important are Monetary Shocks?", *Carnegie-Rochester Conference Series on public Policy* 41, 1-56.

[14] Clark, P.B. (1973), "Uncertainty, Exchange Rate Risk and the Level of International Trade", *Western Economic Journal* 11, 302-313.

[15] Corsetti, G. and P. Pesenti (1997), "Welfare and Macroeconomic Interdependence", working paper, Princeton University.

[16] Côté, A. (1994), "Exchange Rate Volatility and Trade", Working Paper 94-5, Bank of Canada.

[17] Cushman, D.O. (1983), "The Effects of Real Exchange Rate Risk on International Trade", *Journal of International Economics* 15, 45-63.

[18] de Grauwe, P.(1988), "Exchange Rate Variability and the Slowdown in Growth of International Trade", *IMF Staff Papers* 35, 63-84.

[19] Dellas, H. and B.Z. Zilberfarb (1993), "Real Exchange Rate Volatility and International Trade: A Reexamination of the Theory", *Southern Economic Journal* 59, 641-47.

[20] Dixit, A. and J. Stiglitz (1977), "Monopolistic Competition and Optimum Product Diversity", *American Economic Review* 67, 297-308.

[21] Eichenbaum, M. and C.L. Evans (1995), "Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates", *Quarterly Journal of Economics* 60(4), 975-1010.

[22] Engel, C. (1996), "A Model of Foreign Exchange Rate Determination", NBER Working Paper No. 5766.

[23] Engel, C. (1993), "Real Exchange Rates and Relative Prices: An Empirical Investigation", *Journal of Monetary Economics* 32, 35-50.

[24] Ethier, W. (1973), "International Trade and the Foreign Exchange Market", *American Economic Review* 63, 494-503.

[25] Feenstra, R.C. and J.D. Kendall (1991), "Exchange Rate Volatility and International Prices", NBER working paper no. 3644.

[26] Feldstein, M. and C. Horioka, 1980, "Domestic Saving and International Capital Flows", *Economic Journal* 90, 314-329.

[27] Glick, R. and C. Wihlborg (1996), "Exchange Rate Regimes and International Trade", working paper, Federal Reserve Bank of San Francisco.

[28] Giovaninni, A. (1988), "Exchange Rates and Traded Goods Prices", *Journal of International Economics* 24, 45-68.

[29] Helpman, E. (1981), "An Exploration in the Theory of Exchange Rate Regimes", *Journal of Political Economy* 89:5, 865-890.A similar point is made by Glick and Wihlborg (1996).

[30] Helpman, E. and A. Razin (1979), "Towards a Consistent Comparison of Alternative Exchange Rate Systems", *Canadian Journal of Economics* 12:3, 394-409.

[31] Helpman, E. and A. Razin (1982), "A Comparison of Exchange Rate Regimes in the Presence of Imperfect Capital Markets", *International Economic Review* 23, 365-88.

[32] Hooper, P. and W. Kohlhagen (1978), "The Effect of Exchange Rate Uncertainty on the Prices and Volume of International Trade", *Journal of International Economics* 8, 483-511.

[33] Iwamoto, Y. and E. van Wincoop (1998), "Do Borders Matter? Evidence from Japanese Intranational Capital flows", *International Economics Review*, forthcoming.

[34] Kasa, K. (1992), "Adjustment Costs and Pricing to Market. Theory and Evidence", *Journal of International Economics* 32, 1-30.

[35] Kim, S. and N. Roubini (1997), "Liquidity and Exchange Rates in the G-7 Countries: Evidence from Identified VARs", working paper, New York University.

[36] Kindleberger, C.P. (1969), "The Case for Fixed Exchange Rates", in *The International Adjustment Mechanism*, Conference Series no. 2, Federal Reserve Bank of Boston, 93-108. Also in C.P. Kindleberger, *International Money, A Collection of Essays*, George Allen & Unwin, 1981.

[37] Kollmann, T. (1995), "Consumption, Real Exchange Rates and the Structure of International Asset Markets", *Journal of International Money and Finance*, 14:2, 191-211.

[38] Kollmann, R. (1997), "The Exchange Rate in a Dynamic-Optimizing Current Account Model with Nominal Rigidities: A Quantitative Investigation", IMF Working Paper 97/7.

[39] MacDonald, R. and M.P. Taylor (1994), "The Monetary Model of the Exchange Rate: Long Run Relationships, Short-Run Dynamics and How to Beat a Random Walk", *Journal of International Money and Finance* 13(3), 276-290.

[40] Magill, M. and M. Quinzii (1996), *Theory of Incomplete Markets*, MIT Press.

[41] Mark, N.C. (1995), "Exchange Rates and Fundamentals: Evidence on Long Horizon Predictability", *American Economic Review* 85, no. 1, 201-218.

[42] Mark, N.C. and D. Choi (1997), "Real Exchange Rate Predictions over Long Horizons", *Journal of International Economics* 43, 29-60.

[43] McCallum, J. (1995), "National Borders Matter", *American Economic Review* 85, 615-623.

[44] Mundell, R.A. (1961), "A Theory of Optimum Currency Areas", *American Economic Review* 51, 657-65.

[45] Neumeyer, P. A. (1998), "Currencies and the Allocation of Risk: The Welfare Effects of a Monetary Union", *American Economic Review* 88, 246-259.

[46] Obstfeld, M. and K. Rogoff (1995), "Exchange Rate Dynamics Redux", *Journal of Political Economy* 103, 624-60.

[47] Obstfeld, M. and K. Rogoff (1998), "Risk and Exchange Rates", working paper, University of California, Berkeley.

[48] Rankin, N. (1998), "Nominal Rigidity and Monetary Uncertainty in a Small Open Economy", *Journal of Economic Dynamics and Control* 22, 679-702.

[49] Rogers, J. (1998), "Monetary Shocks and Real Exchange Rates", International Finance Discussion Papers, no. 612, Board of Governors of the Federal Reserve System.

[50] Svensson, L.E.O. and S. van Wijnbergen (1989), "Excess Capacity, Monopolistic Competition, and International Transmission of Monetary Disturbances", *Economic Journal* 99, 785-805.

[51] Tille, C. (1998), "The International and Domestic Welfare Effects of Monetary Policy under Pricing-to-Market", working paper, Princeton University.

[52] Viaene, J. and C.G. de Vries (1992), "International Trade and Exchange Rate Volatility", *European Economic Review* 36, 1311-21.

[53] Voss, G.M. (1998), "Monetary Integration, Uncertainty and the Role of Money Finance", *Economica* 65, 231-45.

[54] Wei, S.(1996), "Intra-national versus International Trade: How Stubborn are Nations in Global Integration?", NBER working paper 5531.

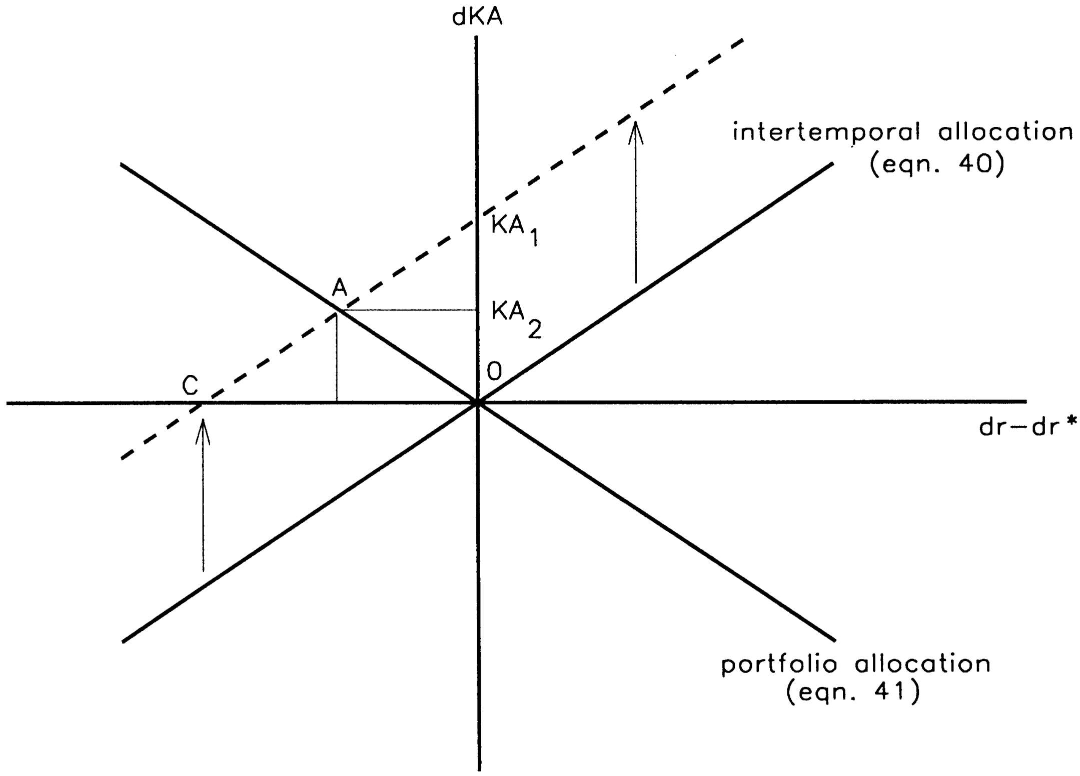
dKA
intertemporal allocation
(eqn. 40)
KA1
A
KA2
0
C
dr−dr*
portfolio allocation
(eqn. 41)

Figure 1