Does Exchange-Rate Stability Increase Trade and Welfare?

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This paper develops a simple general-equilibrium framework to study the effect of the exchange-rate system on trade and welfare. An important feature of the model is deviations from purchasing-power parity, caused by rigid price setting in buyers' currency. In a benchmark model with separable preferences and only monetary shocks, trade is unaffected by the exchange-rate system, consistent with most evidence. In general, both trade and welfare can be higher under either exchange-rate system, depending on preferences and on the monetary-policy rules followed under each system. There is no one-to-one relationship between the levels of trade and welfare across exchange-rate systems. (*JEL* F31, F33, F41)

Exchange-rate stability is often viewed as favorable to trade and therefore welfare enhancing. The well-known 1990 European Community report "One Market, One Money" describes increased trade as one of the main benefits of 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] Moreover, the debate on the implications of the choice of the exchange-rate system basically lacks a sound analytical foundation.

To shed some light on this issue, we develop a stochastic two-country general-equilibrium model incorporating recent developments in open-economy macroeconomics to examine the main mechanisms through which exchange-rate stability affects both trade and welfare. The model is based on microeconomic foundations, which has the advantage of an explicit welfare metric, the utility of the agents.[2] Gross trade flows are modeled in the form of intra-industry trade. Another important feature is deviations from purchasing-power parity (PPP), caused by predetermined price setting in the buyers' currency. While our goal is to present a model rich enough to examine the role of the exchange-rate system, the model is kept simple in order to obtain results that are highly transparent and can be analytically derived. We consider only a one-period version 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 a starting point to investigate an important and difficult issue, highlighting the main factors that determine the impact of the exchange-rate regime on the level of both trade and welfare.

There is growing agreement that a general-equilibrium framework is called for to study exchange-rate fluctuations.[3] A substantial body of literature shows that at horizons of at least

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[1] See Agathe Côté (1994) for a survey. In papers that find a negative relationship, it is generally weak. Although there is evidence that trade is larger within countries than across countries [see, for example, John McCallum (1995)], Shang Jin Wei (1996) finds that exchange-rate uncertainty does not play a significant role in the home-trade bias.

[2] Most of the debate on the optimal choice of an exchange-rate regime is based on nonoptimizing frameworks, such as the optimum currency area literature originating from Robert A. Mundell (1961).

[3] For example, see Maurice Obstfeld and Kenneth Rogoff (1998), who also stress the need for "stochastic general-equilibrium monetary models" that *do not* "rely on a

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 than to 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. The model captures some well-known stylized facts about real exchange rates: they are more volatile in floating than fixed systems and are 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]

Our approach differs from most of the literature by considering PPP deviations in general equilibrium. While there is a literature investigating 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 otherwise deterministic environment. Models that do take a general-equilibrium perspective to investigate the impact of the exchange-rate regime commonly adopt the PPP assumption, so that the real exchange rate is constant.[8]

We base our modeling strategy on recent progress made toward developing general-equilibrium models capturing some of the key stylized facts about exchange rates mentioned above. A popular approach now is to assume pricing-to-market (PTM) in conjunction with Keynesian price rigidity.[9] This approach typically assumes that 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, resulting in a close relationship between nominal and real exchange rates. However, these models have been used primarily to study the dynamic response of the exchange rate and other macroeconomic variables after a monetary shock. Either a deterministic environment is assumed, or uncertainty does not affect decision variables because of linearization.[10] Moreover, although intra-industry trade is present in all these models, it is a dimension that has not been exploited so far.

certainty equivalent assumption to approximate equilibrium relationships."

[4] See Richard Clarida and Jordi Galí (1994), Ronald MacDonald and Mark P. Taylor (1994), Martin Eichenbaum and Charles L. Evans (1995), Nelson C. Mark (1995), Soyoung Kim and Nouriel Roubini (1997), Mark and Doo Yull Choi (1997), and John H. Rogers (1999). 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 Elhanan Helpman and Assaf Razin (1979): "When discussing a floating exchange-rate regime one should consider only exchange-rate patterns which fulfill 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 Reuven Glick and Clas Wihlborg (1997).

[6] Charles 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 Peter B. Clark (1973), Wilfred Ethier (1973), David P. Baron (1976), Peter Hooper and Steven W. Kohlhagen (1978), David O. Cushman (1983), Paul De Grauwe (1988), Robert C. Feenstra and Jon D. Kendall (1991), Jean-Marie Viaene and Casper G. de Vries (1992), and Harris Dellas and Ben Z. Zilberfarb (1993).

[8] This is the case, for example, of Helpman and Razin (1979, 1982), Helpman (1981), Robert E. Lucas, Jr. (1982), Graham M. Voss (1998), Pablo Andres Neumeyer (1998), and Bacchetta and van Wincoop (2000).

[9] Caroline Betts and Michael B. Devereux (1996, 1997, 2000), Engel (1996), V. V. Chari et al. (1997), Robert Kollmann (1997), and Cédric Tille (1998) have developed such models. 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 Avinash Dixit and Joseph Stiglitz (1977)—has been adopted in the subsequent literature as well. See also Giancarlo Corsetti and Paolo Pesenti (2000), who solve a version of the model in closed form.

[10] A recent exception is Devereux and Engel (1998), who consider the welfare implications of different exchange-rate systems in a model with perfect risk sharing. Obstfeld and Rogoff (1998), Neil Rankin (1998), and Lars E. O. Svensson and Sweder van Wijnbergen (1989) also develop open-economy monetary models with nominal rigidities in truly stochastic environments (without linearization). However, these papers assume purchasing-power parity and do not compare the implications of different exchange-rate systems.

Our main findings can be summarized as follows. First, exchange-rate stability is not necessarily associated with more trade. In a simple benchmark model with only monetary shocks, we find that the level of trade is the same under a float as under a fixed exchange-rate system when preferences are separable in consumption and leisure. In general, trade can be higher under either exchange-rate system, depending on preferences and on the monetary-policy rules followed under both systems. These results do not depend on the asset-market structure. Second, we find that a welfare comparison of the two systems depends on individual preferences and the monetary-policy rules that are implemented in each system. We show, for example, that whether a one-sided or cooperative peg is adopted is an important distinction. We also find that when introducing technology and fiscal shocks, the welfare comparison across the two systems depends on the degree of flexibility in monetary-policy response under a float. Finally, in general there is no one-to-one relationship between the levels of trade and welfare across exchange-rate systems. We give several examples where trade is higher under one system, while welfare is higher under the other. The key determinants of trade—the certainty equivalent of firm revenues and costs in the home market relative to the foreign market—are different from the key determinants of welfare—the volatility of consumption and leisure.

The remainder of the paper is organized as follows. Section I develops a one-period general-equilibrium model with uncertainty only from monetary shocks. Section II compares the level of trade under fixed and floating exchange-rate regimes. In Section III we consider what factors affect the level of welfare under a float relative to a fixed exchange-rate system, and whether there is a direct relationship between trade and welfare across exchange-rate systems. Section IV introduces fiscal and technology shocks and discusses the implications for trade and welfare of different monetary-policy rules followed under both systems. The final section concludes and provides suggestions for future research.

I. A Benchmark Monetary Model

In this section, we present a two-country general-equilibrium model where uncertainty comes only from monetary shocks. The model is then used in the following two sections to compare gross trade flows and welfare under fixed and floating exchange-rate regimes.

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. Firms sell differentiated products domestically 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 in advance, i.e., before uncertainty about each country's money supply is resolved. The prices are set in terms of the currency of the country where the goods are sold. A Home-country firm i sets a price $p_H(i)$ in Home currency in the Home market and $p_H^*(i)$ in Foreign currency in the Foreign market. A Foreign-country firm i sets $p_F^*(i)$ in Foreign currency in the Foreign market and $p_F(i)$ in Home currency 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.

A. *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.[11] The unconditional distributions of the money supplies are assumed to be the same under a fixed exchange-rate system as under a float.[12] Under a flexible exchange rate, money supplies are generally different. We assume that

[11] More generally one can think of M and M^* as representing both money-supply and money-demand shocks. While this distinction has no implications for the level of trade, it is relevant when considering welfare implications. We will return to this in the section on welfare, where we introduce explicit money-demand shocks.

[12] This assumption is again important for welfare comparisons, but not for trade.

the distribution of M and M^* is jointly symmetric, with a correlation less than one. Under a fixed exchange-rate system, the correlation is one, that is, $M = M^*$. 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 in finite-horizon models with cash-in-advance constraints, is needed to ensure that sellers of goods are willing to accept money.

B. *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

$$EU(c, l), \tag{1}$$

where E is the expectation operator, l is leisure, and c is a constant-elasticity-of-substitution (CES) consumption index:

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

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.

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):

$$\int_0^1 p_H(i)c(i) \, di + \int_1^2 p_F(i)c(i) \, di = w(1 - l) + \Pi \equiv Y. \tag{3}$$

We refer to the right-hand side of (3) 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

$$u_c \frac{w}{P} = u_l \tag{4}$$

$$c(i) = \frac{1}{2} \left(\frac{p_H(i)}{P} \right)^{-\mu} \frac{Y}{P} \qquad (i \leq 1). \tag{5}$$

Here u_c and u_l are the marginal utilities of consumption and leisure. Equation (4) represents the standard trade-off between consumption and leisure. Equation (5) 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

$$P = \left(\frac{1}{2} \int_0^1 p_H(i)^{1-\mu} \, di + \frac{1}{2} \int_1^2 p_F(i)^{1-\mu} \, di \right)^{1/(1-\mu)}. \tag{6}$$

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.[13] Since Home households receive 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 nominal value of output Y sold 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

[13] 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 shown that the two cases coincide when there are no internationally traded assets.

$$Y = M. \tag{7}$$

C. *Firms*

Each good is produced with one unit of labor. Profits of a Home firm i are

$$\Pi = p_H(i)c(i) + Sp_H^*(i)c^*(i) - w(c(i) + c^*(i)). \tag{8}$$

Home demand is given by (5), using (7). Foreign demand is given analogously by

$$c^*(i) = \frac{1}{2}\left(\frac{p_H^*(i)}{P^*}\right)^{-\mu}\frac{M^*}{P^*}, \tag{9}$$

with the foreign price index P^* defined similarly to (6).

Firms' decisions are made 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.

In setting prices, firm i maximizes the market value of profits, $E(u_c\Pi)$, subject to domestic and foreign demand for its goods, (5) and (9). Optimal prices are[14]

$$p_H(i) = \frac{\mu}{\mu - 1}\frac{Eu_c wM}{Eu_c M} \tag{10}$$

$$p_H^*(i) = \frac{\mu}{\mu - 1}\frac{Eu_c wM^*}{Eu_c SM^*}. \tag{11}$$

Since all domestic firms charge the same price in equilibrium, we refer to these prices as p_H and p_H^*. The optimal price equations for Foreign firms are analogous. Due to symmetry, $p_F = p_H^*$ and $p_F^* = p_H$.

Finally, we need to solve for the equilibrium exchange rate. This follows from the money-market equilibrium condition $M = Y = p_H c_H + Sp_H^* c_H^*$, where $c_H = c(i)$ and $c_H^* = c^*(i)$ for $0 < i < 1$. After substituting the demand functions for domestic goods, we can solve[15]

$$S = \frac{M}{M^*}. \tag{12}$$

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. What matters, though, is that it captures in a simple way the basic idea that the exchange rate is connected to underlying fundamentals, thus illustrating the importance of general-equilibrium analysis. Uncertainty about the fundamentals (the money supplies) not only leads to uncertainty about the exchange rate firms face, but also about the wages they pay and the demand for their goods.

II. Trade and the Exchange-Rate System

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 the Home currency are $Sp_H^* c_H^*$ and imports are $p_F c_F$, we can use the demand functions and symmetry to find

$$Trade = \frac{Exports + Imports}{GDP} = \frac{2}{1 + (p_H/p_H^*)^{1-\mu}}. \tag{13}$$

Hence, results about prices give direct results about trade. Under a fixed exchange-rate regime, where $M = M^*$, it is easily verified from (10) and (11) 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.

[14] These price equations are similar to those in other dynamic general-equilibrium models with PTM, such as Betts and Devereux (1997), Chari et al. (1997), and Kollmann (1997).

[15] To be precise, $M = ½\,(p_H/P)^{1-\mu}M + ½\,(p_H^*/P^*)^{1-\mu}SM^*$. Using (6) and the fact that $P = P^*$ and $p_H^* = p_F$ as a result of symmetry, (12) follows.

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.[16] 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 in the domestic market.

To determine prices fully, we need to substitute for the endogenous variables w and S in (10) and (11). Using (4) and (12), equilibrium prices are

$$p_H = \frac{\mu}{\mu - 1} P \frac{Eu_l M}{Eu_c M} \tag{14}$$

$$p_H^* = \frac{\mu}{\mu - 1} P \frac{Eu_l M^*}{Eu_c M}. \tag{15}$$

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

PROPOSITION 1: *Trade is not necessarily higher under a fixed exchange-rate system than it is under a floating exchange-rate system. In the benchmark monetary model, trade is the same under the two exchange-rate regimes when utility is separable in consumption and leisure. Trade is higher under a fixed exchange-rate system when consumption and leisure are substitutes, but it is lower when they are complements.*

The intuition behind this proposition becomes clear when considering the certainty equivalent of costs and sales. Domestic firms selling in the domestic market face costs and revenues proportional to, respectively, wM and M (with the same proportionality factor). Similarly, costs and revenues in the foreign market are proportional to wM^* and SM^*. It then follows from (10) and (11) that prices in both markets can be written as

$$price = \phi \frac{E\lambda costs}{E\lambda sales} \tag{16}$$

where $\phi = \mu/(1 - \mu)$ is a constant markup and $\lambda = u_c/Eu_c$. λ is a stochastic discount factor, with mean equal to one, used to compute the certainty equivalent of marginal costs and revenues. The price can therefore be written as a markup over the certainty equivalent of costs, divided by the certainty equivalent of sales.

First consider sales. Because $M = SM^*$, revenues are equal in the two markets (at equal prices). 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: 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 the foreign-currency depreciation is the result of either a foreign monetary expansion or a home monetary contraction, which both affect the demand for goods. The increased demand caused by a foreign monetary expansion offsets the loss from the depreciation. A home monetary contraction reduces both demand in the home market and the value of sales in the foreign market due to currency depreciation.

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.[17] This leads to a higher price and lower trade.

[16] 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 the Home currency $p_H < E(Sp_H^*)$, while in the 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 $E(1/S) > 1/E(S)$.

[17] In the partial-equilibrium literature, it is generally assumed that firms maximize the expected value of a concave function of profits. Alberto Giovannini (1988), while also adopting a partial-equilibrium framework, does not find

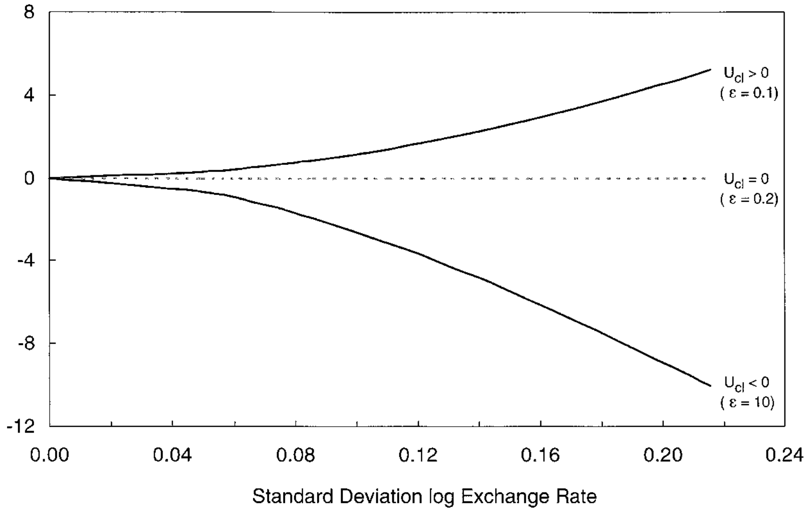

FIGURE 1. PERCENTAGE INCREASE IN TRADE WHEN SWITCHING FROM FIXED TO FLOAT

Notes: The upper schedule represents the case where consumption and leisure are substitutes, while the middle and lower ones represent respectively separability and substitutability of consumption and leisure. See text for the parameter description.

Now consider the numerator of (16), the certainty equivalent of labor costs. In a partial-equilibrium framework, this is 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 are proportional to, respectively, wM and wM^* when selling in the home and foreign markets. Two factors play a role here. First, under separable preferences and a float, the wage rate is more correlated with domestic demand than with foreign demand.[18] 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 in the domestic market and, therefore, more trade under a floating exchange-rate regime. However, labor costs in the domestic market are high exactly when firms can well afford to pay them: sales are high as well.[19] 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.[20] 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. 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. In that case, the second factor dominates, and trade is lower under a float.

These results are illustrated in Figure 1. We

ex ante price discrimination in a model where firms are risk neutral.

[18] 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 $\partial l/\partial M = \partial l/\partial M^*$.

[19] More formally, u_c is lower (and therefore the weight λ) in high M states of the world. This lowers the certainty equivalent of labor costs.

[20] More formally, it is possible that 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.

assume that $U(c, l) = V(c, l)^{1-\nu}/(1 - \nu)$, where $V(c, l)$ is a CES index with ε the elasticity of substitution between consumption and leisure. Consumption and leisure are complements, separable, or substitutes, dependent on whether $\varepsilon\nu$ is respectively smaller than, equal to, or larger than 1. We set $\nu = 5$, $\mu = 5$ (see David Hummels, 1999), and consider three different values of ε (0.1, 0.2, and 10). We assume that M and M^* can take on 11 equidistant values, with mean 0.5 and standard deviation 0.075.[21] Figure 1 shows the percentage increase in trade from a fixed to a floating exchange-rate system as a function of the standard deviation of the exchange rate under a float, whereby we have varied the correlation between M and M^* from 0 to 1. For comparison, the standard deviation of the effective dollar exchange rate is 0.127 over the 1973:1 to 1999:2 period. Consistent with Proposition 1, trade is higher under a float when consumption and leisure are substitutes ($U_{cl} > 0$), lower when they are complements ($U_{cl} < 0$), and equal when they are separable. The numbers in the pictures should not be taken too literally. The model is obviously very simple and trade results are very sensitive to the parameter μ. The percentage change in trade from fixed to a float approximately doubles when μ is raised to 10.

In our model there is no international trade in assets and, therefore, also no forward market to hedge exchange-rate uncertainty. In the context of partial-equilibrium models, it has been argued that trade is unaffected by exchange-rate risk when firms have access to a forward market.[22] This is not the case in our context. Actually, the key results of this section hold under any type of international asset-market structure.

With international trade in assets, our previous measure of trade in goods—exports plus imports divided by GDP—becomes stochastic. We therefore modify the definition of trade as the certainty equivalent of exports plus imports, divided by the certainty equivalent of GDP. Under this definition, Proposition 1 still holds without trade in assets. Both with and without trade in assets, the certainty equivalent measure of trade is equal to the function of p_H/p_H^* on the right-hand side of (13). Using this trade measure, the following proposition is proven in Appendix B.[23]

PROPOSITION 2: *Proposition 1 still holds once international trade in assets is introduced, for any asset-market structure.*

This implies that in general the exchange-rate regime matters even when financial markets are complete. While Helpman (1981) and Lucas (1982) find that fixed and floating exchange-rate regimes lead to identical Pareto-efficient outcomes when financial markets are complete and prices are flexible, Helpman and Razin (1982) already conjectured that this may not be the case once price rigidities are introduced. As is well known,[24] under complete markets the ratio of the marginal utilities of consumption of two countries is proportional to the real exchange rate. When prices are rigid, the real exchange rate moves together with the nominal exchange rate; in our model, $U_c/U_{c^*} = 1/S$. Therefore, while consumption levels in the two countries are equal under a fixed exchange-rate system, they are not under a float, and neither are leisure and wage rates. Although all of these variables are quantitatively affected by trade in assets, qualitatively international trade in assets does not change the results for trade in goods.

To summarize, we found that in the context of a simple monetary general-equilibrium model, the level of international trade is not necessarily higher under a fixed exchange-rate system than it is under a floating exchange-rate system. Under separable preferences the level of trade is not affected by the exchange-rate system at all, while under nonseparable prefer-

[21] A final assumption is that the weight of the CES index is set such that $l = 0.5$ in the deterministic equilibrium, assuming that time (other than sleep and household chores) is equally divided between work and leisure.

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

[23] Although the countries can freely trade assets, we assume that firm ownership is domestic, so that the marginal utility of domestic residents is used to compute the certainty equivalent of profits. As discussed in Bacchetta and van Wincoop (1998), allowing foreign residents to be part owners does not affect the results when asset markets are complete but can change results under incomplete markets.

[24] See, for example, David K. Backus and Gregor W. Smith (1993), Kollmann (1995), Prakash Apte et al. (1997), and Betts and Devereux (1998).

ences trade may be higher under either exchange-rate system.

III. Welfare and the Exchange-Rate System

A fundamental issue in international macroeconomics is the optimal choice of the exchange-rate regime. The framework developed in this paper naturally lends itself to a welfare comparison across policy regimes since consumers' utility gives an explicit welfare metric. Several other authors have looked at the optimality of the exchange-rate regime in general-equilibrium optimizing models. However, they typically assume flexible prices.[25] Moreover, our model enables us to examine the relationship between trade and welfare.

The following two propositions summarize our key findings with regard to welfare.

PROPOSITION 3: *Welfare is not necessarily higher under a fixed exchange-rate system than it is under a floating exchange-rate system. The exchange-rate system under which welfare is highest depends on (i) preferences and (ii) the precise monetary-policy rules followed under each exchange-rate system.*

PROPOSITION 4: *In general there is no one-to-one relationship between the relative level of trade and the welfare ordering of exchange-rate regimes.*

Together with Proposition 1, these results suggest that the view that exchange-rate stability leads to more trade and therefore higher welfare may be incorrect.

The key factors determining welfare are the variance of consumption and leisure under both regimes, as well as their covariance under nonseparable preferences. These factors are different from those determining the trade level, which are the variance of revenues and labor costs in the home relative to the foreign market. Another factor affecting welfare, but not trade, is the difference of the overall consumer price index across exchange-rate regimes.[26]

In illustrating the two propositions, we will first consider the role of preferences. We show that a flexible exchange rate leads to higher welfare when preferences are separable, but a fixed exchange rate may be preferred when consumption and leisure are substitutes. We then consider the role of the precise implementation of the exchange-rate systems (the monetary rules followed). We show that a fixed exchange rate is more desirable if it is operated as a cooperative peg, while the opposite is true if it is operated as a one-sided peg. For space limitations, we only discuss the intuition behind the results of this section. Formal proofs are in a technical Appendix that is available on request.

A. *The Role of Preferences*

First, consider the case where preferences are separable in consumption and leisure and where the unconditional distribution of M is the same under both exchange-rate regimes. It can be shown that welfare is higher under a float when agents are risk averse with respect to leisure.[27]

In order to understand this result, it is useful to write down the equations for aggregate Home consumption and leisure in equilibrium:

$$c = \frac{M}{P} \tag{17}$$

$$l = 1 - \frac{1}{2}\frac{M + M^*}{P}. \tag{18}$$

At a given price level, the variance of consumption is the same under both systems, but the variance of leisure is smaller under a float. The disadvantage of a fixed exchange-rate system is that the perfect correlation of domestic and

[25] When markets are complete and prices are flexible, the exchange-rate regime does not matter (Helpman, 1981; Lucas, 1982). Helpman and Razin (1982) and Neumeyer (1998) examine welfare under incomplete markets and flexible prices, and state conditions under which a flexible exchange rate is superior to a fixed exchange rate. As in this paper, Devereux and Engel (1998) have considered this question within the context of a model with nominal rigidities.

[26] Devereux and Engel (1998) discuss in detail the distinction between the effect of the exchange-rate regime on expected levels of consumption and leisure (through the price) and the variance of consumption and leisure.

[27] This is true subject to the condition that the third-order derivative u_{lll} is not too negative.

foreign demand shocks leads to a larger volatility of leisure, which reduces welfare.

Welfare also depends on the price level P under the two systems. Because of monopolistic competition, prices set by firms are inefficiently high. It can be shown that the price level is lower under a float, further contributing to higher welfare. Under a float, the wage rate is less correlated with the demand for goods in both markets, so that the volatility of total labor costs is lower and firms charge a lower price.[28]

An implication of this result is that there is no direct relationship between the level of trade and welfare under the two exchange-rate systems (Proposition 4). We saw in Section II that the level of trade is the same in both exchange-rate systems when utility is separable in consumption and leisure.

The impact of nonseparabilities between consumption and leisure is best understood by examining a specific case where agents are risk neutral with respect to leisure. In that case, welfare is the same under both systems under separable preferences, allowing us to focus on the role of nonseparabilities. Consider the following preferences:

$$U(c, l) = u(c) + l + \alpha cl, \tag{19}$$

where the parameter α measures the degree of nonseparability.

In general, it is difficult to compare the welfare levels under the two exchange-rate systems with nonseparable preferences because p_H and p_H^* are not equal and their equilibrium levels are different under the two systems. In order to obtain an analytical result, we therefore consider the welfare effect of a marginal drop in the correlation between the money supplies when starting from a fixed exchange-rate system, where $p_H = p_H^*$, holding the variance of money supplies constant. Differentiating expected utility (19) with respect to the correlation between money supplies and using the equilibrium-price equations (14) and (15), we find that welfare is higher under a float when consumption and leisure are complements and higher under a fixed exchange-rate system when consumption and leisure are substitutes. The intuition for this is that consumption and leisure are more negatively correlated under a fixed exchange-rate system, which is attractive when consumption and leisure are substitutes, but unattractive when they are complements.

In this particular example, the welfare ranking of the exchange-rate systems happens to be the same as the trade ranking. But as we saw above, this does not hold generally since leisure has a lower volatility under a float. Therefore, when agents are significantly risk averse with respect to leisure, while consumption and leisure are weak substitutes, welfare is higher under a float but trade is higher under a fixed exchange rate.

These findings are further illustrated in Figure 2. It shows the welfare gain from a fixed exchange rate to a float for the same utility function and parameterization on which Figure 1 is based. In this case there is positive risk aversion with respect to leisure. The welfare gain is defined as the equal percentage change in consumption and leisure under a fixed exchange rate that leads to the same welfare as under a float. Figure 2 illustrates that welfare can be higher under either exchange-rate system. Welfare is higher under a float when consumption and leisure are complements, separable, or weak substitutes. Welfare is lower under a float when consumption and leisure are sufficiently strong substitutes. The figure also illustrates that the welfare and trade ordering of exchange-rate systems can differ. This is the case for $\varepsilon = 0.3$ (weak substitutes), in which case welfare is larger under a float, while trade is larger under a fixed exchange rate.

[28] Devereux and Engel (1998) also find that welfare is higher under a float in a model with nominal rigidities and separable preferences. They compare welfare under different assumptions about price setting. While their model is somewhat different—they consider an infinite-horizon, two-country general-equilibrium model with perfect risk sharing and money in the utility function—their conclusion that welfare is higher under a float when there is pricing-to-market, and when preferences are separable in consumption and leisure, is the same as ours. In their framework, the third-order derivative plays no role because they assume that utility is quadratic in leisure. More generally, the third-order derivative matters because the certainty equivalent of the wage rate is proportional to Eu_l, which is lower under a float when $u_{lll} > 0$, in which case it further contributes to a lower price.

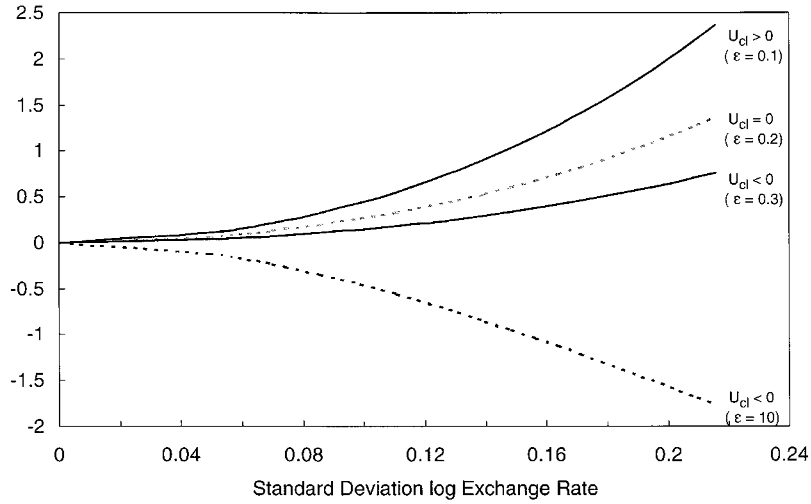

FIGURE 2. WELFARE GAIN WHEN SWITCHING FROM FIXED TO FLOAT

Notes: The welfare gain is the percentage increase in consumption and leisure under a fixed exchange-rate regime needed to maintain the same utility as under a float. The results are based on the same utility function and parameterization as Figure 1.

B. *The Role of Monetary Rules*

Apart from preferences, a welfare comparison across exchange-rate regimes depends on how a particular exchange-rate system is managed. Neither exchange-rate system ties down the monetary-policy rules followed. Under a float, the exchange-rate system does not impose any restrictions on monetary policy at all.[29] Under a fixed exchange-rate system, there is also a degree of freedom with respect to monetary-policy rules, which can be determined symmetrically in a cooperative peg or asymmetrically, for example in a unilateral peg. As an illustration, we examine a situation where central banks are faced with unobservable money-demand shocks, and we compare a cooperative peg with a one-sided peg. We show that the welfare ordering between fixed and flexible exchange rates is different in the two cases.

As discussed above, in general one can think of M as a combination of money demand and supply shocks. When we introduce a stochastic velocity V of money demand, the money-market equilibrium condition becomes $Y/V = M^s$, where M^s is the money supply.[30] All we need to do is reinterpret M as M^sV. Similarly, $M^* = M^{s*}V^*$. Under a pure float, we assume that money supplies are constant because the central bank cannot instantaneously respond to the unobservable shocks to V and V^*. Assuming money supplies equal to one, we then have $M = V$ and $M^* = V^*$ under a float, so that $S = V/V^*$.

Under a fixed exchange-rate system, however, by targeting the exchange rate the money supplies automatically respond to V and V^*, even though they are not immediately observable. First consider a one-sided peg, where the Foreign central bank pegs to the Home currency. The Home country's monetary policy is the same as it is under a float ($M^s = 1$), while M^{s*} adjusts endogenously to set $S = 1$. In that case, $M = M^* = V$. Assuming that V and V^* have the same unconditional distribution, it follows that the unconditional distributions of M and M^* are the same as under a float. As

[29] Neumeyer (1998) argues that welfare may be higher or lower under a float depending on whether the central bank is independent from political influence, which affects the volatility of money supplies.

[30] See, for example, Henning Bohn (1990) for an explicit model of velocity shocks in the presence of cash in advance constraints.

discussed above, in this case welfare will be higher under a float when utility is separable in consumption and leisure.

A cooperative peg can be implemented in different ways. Here we consider it as the limit of $k \to \infty$ of the following symmetric exchange-rate targeting rules:

$$\frac{1}{M^S} = 1 + k(S - 1)$$

$$\frac{1}{M^{S*}} = 1 + k\left(\frac{1}{S} - 1\right).$$

A pure float is represented by $k = 0$. Intermediate values of k represent a managed float, which we will not consider here. Substituting $S = M^S V/(M^{S*}V^*)$, when $k \to \infty$, $M = M^* = (V + V^*)/2$. The results are now opposite to those under a one-sided peg. For a given price level, leisure is equally volatile as under a float, while consumption is less volatile. Assuming preferences that are separable in consumption and leisure and quadratic (so that third-order derivatives do not matter), it can then be shown that welfare is higher under a cooperative peg than it is under a float. The reason is that under a cooperative peg the idiosyncratic components of velocity shocks are automatically stabilized through exchange-rate targeting.

While the precise implementation of the fixed exchange-rate system has significant welfare implications in this example, it does not affect the level of trade. Our trade results do not depend on the relative volatility of M in the two systems, only on the higher correlation between M and M^* under a fixed exchange-rate system. To summarize, we can say that in general there is no direct relationship between the level of trade and welfare under different exchange-rate systems, while a welfare comparison between fixed and floating exchange-rate systems depends both on preferences and on how the exchange-rate systems are managed. We return to these issues in the next section, where we introduce other shocks.

IV. Other Sources of Uncertainty

In the traditional analyses of exchange-rate regimes, the source of shocks plays a significant role. The benchmark monetary model can easily be extended to include other sources of shocks, such as government spending and productivity shocks. Comparisons across exchange-rate systems, with regard to both trade and welfare, turn out to depend crucially on the correlations between money supplies and the other shocks and on how these correlations change across regimes. To illustrate this point, we consider the case of productivity shocks with specific monetary rules. We assume that the technology shocks are observable, which enables central banks to respond to these shocks through their monetary policy. Under a float, central banks have typically more flexibility in responding to idiosyncratic shocks, which affects the correlation between the money supply and the other shocks.

Throughout the section, 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 monetary shocks. The only difference with the benchmark model is that the production of goods requires $1/a$ units of labor at home and $1/a^*$ abroad. These productivity parameters are stochastic, and we assume that $Ea = Ea^* = 1$. Profits of domestic firms 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 $c(i) = \frac{1}{2}(p_H(i)/P)^{-\mu}(M/P)$, and $c^*(i) = \frac{1}{2}(p_H^*(i)/P^*)^{-\mu}(M^*/P^*)$. Optimal prices are

$$p_H(i) = \frac{\mu}{\mu - 1}\frac{Eu_c(w/a)M}{Eu_cM} \tag{20}$$

$$p_H^*(i) = \frac{\mu}{\mu - 1}\frac{Eu_c(w/a)M^*}{Eu_cSM^*}. \tag{21}$$

The nominal exchange rate is still given by (12).

We consider a monetary rule where the money supply can potentially be used to stabilize domestic employment under a floating exchange-rate system. Assume the following monetary rules:

$$M = m + \gamma(a - 1) \tag{22}$$

$$M^* = m^* + \gamma(a^* - 1). \tag{23}$$

The first components of the rules, m and m^*, are similar to money supplies in the previous sections. We assume that m and m^* are independent of a and a^* and that their unconditional distributions are the same under each exchange-rate system. Then there are two parameters of the monetary rules that can differ across the exchange-rate systems: γ and $\rho = \text{corr}(m, m^*)$. Under a fixed exchange-rate system, $\rho = 1$ and $\gamma = 0$. Only under a float can γ be different from zero. It is often considered an advantage of a float that monetary policy can respond to idiosyncratic shocks in order to stabilize the business cycle. When $\gamma > 0$, monetary policy reduces the volatility of employment.

First consider the case where $\gamma = 0$ under both systems, so that the only difference is that $\rho < 1$ under a float. This case is similar to that considered in Section II and at the beginning of Section III, subsection A. It is still the case that trade is the same under the two systems, while welfare is higher under a float.

The results are different when monetary policy reduces the volatility of employment under a float ($\gamma > 0$), while $\rho = 1$ under both systems. Using a proof similar to that for Proposition 1 in Appendix A, it can be shown that trade is higher under a fixed exchange-rate system. The certainty equivalent of revenue under a float remains equal in both markets, but the certainty equivalent of labor costs is lower when selling goods in the domestic market. The monetary policy under a float stabilizes domestic labor demand, making it more attractive to sell goods in the domestic market, which reduces trade. This contrasts with the case where M and M^* are independent of a and a^*, where trade is the same under both exchange-rate systems. Thus, the impact of exchange-rate uncertainty on trade crucially depends on the specific monetary rules.

When $\gamma > 0$ under a float, welfare may be higher under either exchange-rate system, depending on the degree of risk aversion with respect to consumption and leisure. As was the case for nonseparable preferences, analyzing welfare implications is complicated by the fact that the prices p_H and p_H^* are not equal under a float. We deal with this by considering a marginal deviation from a fixed exchange-rate system. We differentiate expected utility with respect to γ, measured at $\gamma = 0$, using the price equations above. When utility is quadratic, it can be shown that the welfare effect depends on a weighted average of the effects on the variance of consumption and leisure.[31] The weights depend on the degree of risk aversion with respect to consumption and leisure. While the stabilizing role of monetary policy under a float leads to a lower volatility of leisure, which is welfare enhancing, it increases the volatility of consumption. Depending on which of these effects dominates, it can go either way.[32]

Government spending shocks can also easily be introduced in the model. The details are in the technical Appendix that is available on request.[33] The analysis and the conclusions are broadly similar to the case with technology shocks. Monetary policy under a float that stabilizes employment again leads to less trade than under a fixed exchange-rate system, while the welfare effect is ambiguous. These results illustrate that comparisons across exchange-rate regimes should take into account a possible difference across systems in the monetary-policy response to demand and supply shocks. The examples also illustrate that the ordering of trade levels across exchange-rate systems can be opposite to the welfare ordering.

V. Conclusion

Our analysis has potentially interesting implications for the policy debate on exchange-rate volatility and the optimal exchange-rate regime. First, we find that adopting a fixed exchange-rate system does not necessarily lead to more trade. In a simple benchmark model with separable preferences and only monetary shocks, trade is unaffected by the exchange-rate

[31] This welfare result is formally proven in the technical Appendix that is available on request.

[32] The ordering of trade and welfare across the exchange-rate systems changes if we assume that $\gamma < 0$ under a float. In that case trade is higher under a float. Welfare is unambiguously lower under a float as this "bad" policy increases the volatility of both leisure and consumption.

[33] We consider the following monetary-policy rules: $M = m + (1 - \gamma)(G - 1)$ and $M^* = m^* + (1 - \gamma)(G^* - 1)$, where G and G^* represent random government consumption, which enters utility separable from private consumption and leisure and which is financed by lump-sum taxes.

system, consistent with most evidence. Second, for both trade and welfare a comparison across exchange-rate systems depends crucially on precisely how each system is implemented. For example, it can make a big difference whether a one-sided or cooperative peg is adopted, and how the degree of policy flexibility under a float is used to respond to idiosyncratic demand and supply shocks. Finally, we find that more trade does not always correspond to higher welfare. We have given many examples where trade is higher under one exchange-rate system, while welfare is higher under the other. The determinants of trade are different from the determinants of welfare.

The model can be extended in many ways since we have purposefully kept it as simple as possible. In Bacchetta and van Wincoop (1998) we examine the impact of the exchange-rate regime on net capital flows in a two-period version of the model. We show that net capital flows tend to be smaller under a flexible exchange-rate regime. Another obvious extension is to consider an infinite-horizon framework. Although this extension is technically challenging when financial markets are incomplete, it is likely to be important, as the exchange rate will be affected by expectations associated with *future* fundamentals. Our model has 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 foreign direct investment 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 are likely to provide further insight.

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, $Ef(M, M^*)(M - M^*) < (>)(=)0$ when $\partial f/\partial M < (>)(=)\partial f/\partial M^*$ $\forall M, M^*$.*

PROOF OF LEMMA 1:

Without loss of generality, assume a state space $[0, 2Z]$ with $\pi(\cdot)$ the probability density function. Since M and M^* have a symmetric distribution we may assume, again without loss of generality, that for any $z \leq Z$, $M(z) = M^*(z + Z)$, $M^*(z) = M(z + Z)$, and $\pi(z) = \pi(z + Z)$. Therefore $Ef(M, M^*)(M - M^*) = \int_{z=0}^{2Z} \pi(z) f(M(z), M^*(z))(M(z) - M^*(z))\, dz$ is equal to $\int_{z=0}^{Z} \pi(z)(M(z) - M(z + Z))[f(M(z), M(z + Z)) - f(M(z + Z), M(z))]\, dz$. Assume without loss of generality that $M(z) > M(z + Z)$. Then $f(M(z), M(z + Z)) - f(M(z + Z), M(z)) = \int_{x=0}^{M(z)-M(z+Z)} [\partial/\partial M - \partial/\partial M^*] f(M(z + Z) + x, M(z) - x)dx$. Lemma 1 follows immediately.

PROOF OF PROPOSITION 1:

From (10) and (15), trade is lower when $Eu_l(M - M^*) < 0$. We can apply Lemma 1, using $f(M, M^*) = u_l$, $c = M/P$, $l = 1 - ½ (p_H/P)^{-\mu}M/P - ½ (p_H^*/P)^{-\mu}M^*/P$. It follows that

$$\text{(A1)} \quad \frac{\partial f}{\partial M} - \frac{\partial f}{\partial M^*} = \frac{1}{P} u_{cl} + \frac{1}{2}\frac{1}{P} u_{ll}[(p_H^*/P)^{-\mu} - (p_H/P)^{-\mu}].$$

When utility is separable in consumption and leisure, $p_H = p_H^*$ follows by contradiction. If $p_H^* > p_H$, $\partial f/\partial M - \partial f/\partial M^* > 0$ because $u_{ll} < 0$. Lemma 1 then tells us that $Eu_l(M - M^*) > 0$. From (14) and (15) 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 $p_H \leq p_H^*$, $\partial f/\partial M - \partial f/\partial M^* > 0$ from (A1). From Lemma 1, (14), and (15) 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: PROOF OF PROPOSITION 2

Let the total net payoff of assets by θ in home currency for Home residents and θ^* in foreign currency for Foreign residents ($\theta + S\theta^* = 0$). The following first-order condition applies:

$$\text{(B1)} \qquad Eu_c\theta = 0.$$

Define $\tilde{Y} = M + \theta$ and $\tilde{Y}^* = M^* + \theta^*$. The new money-market equilibrium condition is

$$\text{(B2)} \quad M = Y = p_H c_H + Sp_H^* c_H^*$$
$$= \frac{1}{2}\left(\frac{p_H}{P}\right)^{1-\mu}\tilde{Y} + \frac{1}{2}S\left(\frac{p_H^*}{P}\right)^{1-\mu}\tilde{Y}^*.$$

Trade is measured as the certainty equivalent of exports plus imports, divided by the certainty equivalent of GDP. Using $p_F = p_H^*$, the value of exports is equal to $0.5(p_H^*/P)^{1-\mu}\tilde{Y}$, while the value of imports in the Home currency is equal to $0.5(p_H^*/P)^{1-\mu}S\tilde{Y}^*$. From (B1) it follows that $Eu_cM = Eu_c\tilde{Y}$. Multiplying (B2) by u_c, taking expectations, using $Eu_cM = Eu_c\tilde{Y}$, it follows that $Eu_c\tilde{Y} = Eu_cS\tilde{Y}^*$. Therefore the measure of trade, $Eu_c(Exports + Imports)/Eu_cM$, is equal to $(p_H^*/P)^{1-\mu}$, the same as the expression on the right-hand side of (13).

Optimal prices are now

$$\text{(B3)} \qquad p_H = \frac{\mu}{\mu - 1} P \frac{Eu_l\tilde{Y}}{Eu_c\tilde{Y}}$$

$$\text{(B4)} \qquad p_H^* = \frac{\mu}{\mu - 1} P \frac{Eu_l\tilde{Y}^*}{Eu_cS\tilde{Y}^*}.$$

Since $Eu_c\tilde{Y} = Eu_cS\tilde{Y}^*$, the sign of $p_H - p_H^*$ is equal to the sign of $Eu_l(\tilde{Y} - \tilde{Y}^*)$. This is the same as we found in the absence of trade in assets, with M and M^* replaced by $\tilde{Y}$ and $\tilde{Y}^*$. c and l depend on $\tilde{Y}$ and $\tilde{Y}^*$ in the same way as they previously were functions of M and M^*. The conditions leading to Proposition 1 therefore still hold.

It remains to be shown that there is no asset-market structure under a float where $\tilde{Y} = \tilde{Y}^*$ for all states of the world. The proof is 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 $p_H = p_H^*$. Substituting this in (B2), we have $S = M/M^*$. Then $\tilde{Y} = \tilde{Y}^*$ implies $\theta = [M(M^* - M)/(M + M^*)]$ and $\theta^* = [M^*(M - M^*)/(M + M^*)]$. The foreign counterpart to (B1) is $Eu_{c^*}\theta^* = 0$. Since $c = c^*$, it follows that $u_c = u_{c^*}$ and therefore $Eu_c(\theta + \theta^*) = 0$. But $Eu_c(\theta + \theta^*) = -Eu_c[(M - M^*)^2/(M + M^*)] < 0$. This establishes a contradiction, which proves Proposition 2.

REFERENCES

Apte, Prakash; Sercu, Piet and Uppall, Raman. "The Exchange Rate and Purchasing Power Parity in Arbitrage-Free Models of Asset Pricing." Mimeo, University of British Columbia, 1997.

Bacchetta, Philippe and van Wincoop, Eric. "Does Exchange Rate Stability Increase Trade and Capital Flows?" National Bureau of Economic Research (Cambridge, MA) Working Paper No. 6704, August 1998.

______ . "Trade in Nominal Assets and Net International Capital Flows." *Journal of International Money and Finance*, February 2000, *19*(1), pp. 55–72.

Backus, David K. and Smith, Gregor W. "Consumption and Real Exchange Rates in Dynamic Economies with Non-traded Goods." *Journal of International Economics*, November 1993, *35*(3–4), pp. 297–316.

Baron, David P. "Flexible Exchange Rates, Forward Markets, and the Level of Trade." *American Economic Review*, March 1976, *66*(3), pp. 253–66.

Betts, Caroline and Devereux, Michael B. "The Exchange Rate in a Model of Pricing-to-Market." *European Economic Review*, April 1996, *40*(3–5), pp. 1007–21.

______ . "The International Monetary Transmission Mechanism: A Model of Real Exchange Rate Adjustment under Pricing-to-Market." Mimeo, University of British Columbia, 1997.

______ . "Exchange Rate Dynamics in a Model of Pricing-to-Market." *Journal of International Economics*, February 2000, *50*(1), pp. 215–44.

Bohn, Henning. "A Positive Theory of Foreign Currency Debt." *Journal of International Economics*, November 1990, *29*(3–4), pp. 273–92.

Chari, V. V.; Kehoe, Patrick J. and McGrattan, Ellen R. "Monetary Shocks and Real Exchange Rates in Sticky Price Models of International Business Cycles." National Bureau of Economic Research (Cambridge, MA) Working Paper No. 5876, January 1997.

Clarida, Richard and Galí, Jordi. "Sources of Real Exchange-Rate Fluctuations: How Important Are Nominal Shocks?" *Carnegie-Rochester Conference Series on Public Policy*, December 1994, *41*, pp. 1–56.

Clark, Peter B. "Uncertainty, Exchange Rate Risk and the Level of International Trade." *Western Economic Journal*, September 1973, *11*(3), pp. 302–13.

Corsetti, Giancarlo and Pesenti, Paolo. "Welfare and Macroeconomic Interdependence." *Quarterly Journal of Economics*, 2000 (forthcoming).

Côté, Agathe. "Exchange Rate Volatility and Trade." Bank of Canada Working Paper No. 94-5, 1994.

Cushman, David O. "The Effects of Real Exchange Rate Risk on International Trade." *Journal of International Economics*, August 1983, *15*(1–2), pp. 45–63.

De Grauwe, Paul. "Exchange Rate Variability and the Slowdown in Growth of International Trade." *International Monetary Fund Staff Papers*, March 1988, *35*(1), pp. 63–84.

Dellas, Harris and Zilberfarb, Ben Z. "Real Exchange Rate Volatility and International Trade: A Reexamination of the Theory." *Southern Economic Journal*, April 1993, *59*(4), pp. 641–47.

Devereux, Michael B. and Engel, Charles. "Fixed vs. Floating Exchange Rates: How Price Setting Affects the Optimal Choice of Exchange-Rate Regime." Mimeo, University of Washington, 1998.

Dixit, Avinash and Stiglitz, Joseph. "Monopolistic Competition and Optimum Product Diversity." *American Economic Review*, June 1977, *67*(3), pp. 297–308.

Eichenbaum, Martin and Evans, Charles L. "Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates." *Quarterly Journal of Economics*, November 1995, *110*(4), pp. 975–1010.

Engel, Charles. "Real Exchange Rates and Relative Prices: An Empirical Investigation." *Journal of Monetary Economics*, August 1993, *32*(1), pp. 35–50.

______. "A Model of Foreign Exchange Rate Determination." National Bureau of Economic Research (Cambridge, MA) Working Paper No. 5766, September 1996.

Ethier, Wilfred. "International Trade and the Foreign Exchange Market." *American Economic Review*, June 1973, *63*(3), pp. 494–503.

Feenstra, Robert C. and Kendall, Jon D. "Exchange Rate Volatility and International Prices." National Bureau of Economic Research (Cambridge, MA) Working Paper No. 3644, March 1991.

Giovannini, Alberto. "Exchange Rates and Traded Goods Prices." *Journal of International Economics*, February 1988, *24*(1/2), pp. 45–68.

Glick, Reuven and Wihlborg, Clas. "Exchange Rate Regimes and International Trade," in Benjamin J. Cohen, ed., *International trade and finance: New frontiers for research.* Cambridge: Cambridge University Press, 1997, pp. 125–56.

Helpman, Elhanan. "An Exploration in the Theory of Exchange Rate Regimes." *Journal of Political Economy*, October 1981, *89*(5), pp. 865–90.

Helpman, Elhanan and Razin, Assaf. "Towards a Consistent Comparison of Alternative Exchange Rate Systems." *Canadian Journal of Economics*, August 1979, *12*(3), pp. 394–409.

______. "A Comparison of Exchange Rate Regimes in the Presence of Imperfect Capital Markets." *International Economic Review*, June 1982, *23*(2), pp. 365–88.

Hooper, Peter and Kohlhagen, Steven W. "The Effect of Exchange Rate Uncertainty on the Prices and Volume of International Trade." *Journal of International Economics*, November 1978, *8*(4), pp. 483–511.

Hummels, David. "Toward a Geography of Trade Costs." Mimeo, University of Chicago, 1999.

Kim, Soyoung and Roubini, Nouriel. "Liquidity and Exchange Rates in the G-7 Countries: Evidence from Identified VARs." Mimeo, New York University, 1997.

Kollmann, Robert. "Consumption, Real Exchange Rates and the Structure of International Asset Markets." *Journal of International Money and Finance*, April 1995, *14*(2), pp. 191–211.

______. "The Exchange Rate in a Dynamic-Optimizing Current Account Model with

Nominal Rigidities: A Quantitative Investigation." International Monetary Fund Working Paper No. 97/7, 1997.

Lucas, Robert E., Jr. "Interest Rates and Currency Prices in a Two-Country World." *Journal of Monetary Economics*, November 1982, *10*(3), pp. 335–59.

MacDonald, Ronald and Taylor, Mark P. "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*, June 1994, *13*(3), pp. 276–90.

Mark, Nelson C. "Exchange Rates and Fundamentals: Evidence on Long-Horizon Predictability." *American Economic Review*, March 1995, *85*(1), pp. 201–18.

Mark, Nelson C. and Choi, Doo Yull. "Real Exchange-Rate Predictions over Long Horizons." *Journal of International Economics*, August 1997, *43*(1–2), pp. 29–60.

McCallum, John. "National Borders Matter." *American Economic Review*, June 1995, *85*(3), pp. 615–23.

Mundell, Robert A. "A Theory of Optimum Currency Areas." *American Economic Review*, September 1961, *51*(4), pp. 657–65.

Neumeyer, Pablo Andres. "Currencies and the Allocation of Risk: The Welfare Effects of a Monetary Union." *American Economic Review*, March 1998, *88*(1), pp. 246–59.

Obstfeld, Maurice and Rogoff, Kenneth. "Exchange Rate Dynamics Redux." *Journal of Political Economy*, June 1995, *103*(3), pp. 624–60.

______ . "Risk and Exchange Rates." National Bureau of Economic Research (Cambridge, MA) Working Paper No. 6694, August 1998.

Rankin, Neil. "Nominal Rigidity and Monetary Uncertainty in a Small Open Economy." *Journal of Economic Dynamics and Control*, May 1998, *22*(5), pp. 679–702.

Rogers, John H. "Monetary Shocks and Real Exchange Rates." *Journal of International Economics*, December 1999, *49*(2), pp. 269–88.

Svensson, Lars E. O. and van Wijnbergen, Sweder. "Excess Capacity, Monopolistic Competition, and International Transmission of Monetary Disturbances." *Economic Journal*, September 1989, *99*(397), pp. 785–805.

Tille, Cédric. "The International and Domestic Welfare Effects of Monetary Policy under Pricing-to-Market." Mimeo, Federal Reserve Bank of New York, 1998.

Viaene, Jean-Marie and de Vries, Casper G. "International Trade and Exchange Rate Volatility." *European Economic Review*, August 1992, *36*(6), pp. 1311–21.

Voss, Graham M. "Monetary Integration, Uncertainty and the Role of Money Finance." *Economica*, May 1998, *65*(258), pp. 231–45.

Wei, Shang Jin. "Intra-National versus International Trade: How Stubborn Are Nations in Global Integration?" National Bureau of Economic Research (Cambridge, MA) Working Paper No. 5531, April 1996.