Global Monetary Policy under a Dollar Standard\textsuperscript{1}

Michael B. Devereux
University of British Columbia and CEPR

Kang Shi
University of British Columbia

Juanyi Xu
University of British Columbia

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Abstract For the past four or five decades, the international monetary system has operated on a ‘dollar standard’. Popular discussion suggests that this gives the US an advantage in the use of monetary policy. This paper analyzes the determination of monetary policy in a world with a dollar standard, defined here as a environment in which all traded goods prices are set in US dollars. This generates an asymmetry whereby exchange rate pass-through into the US CPI is zero, while pass-through to other countries will be positive. We show that monetary policy in such a setting does seem to accord with popular discussion. In particular, the US is essentially indifferent to exchange rate volatility in setting monetary policy, while the rest of the world places a high weight on exchange rate volatility. More importantly, in a Nash equilibrium of the monetary policy game between the US and the rest of the world, the preferences of the US dominate. That is, the equilibrium is identical to one where the US alone chooses world monetary policy. Despite this, we find surprisingly that the US loses from the dollar’s role as an international currency. Even though US preferences dominate world monetary policy, the absence of exchange rate pass-through means that US consumers are worse off than those in the rest of the world, where exchange rate pass-through operates efficiently. Finally, we derive the conditions for a dollar standard to exist.

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1 Introduction

If the dollar were ever displaced by the euro, [the US].. would lose the enormous freedom it now enjoys in running macro-economic policy.


The US dollar occupies a unique role in the world economy. The dollar resembles an international currency, in the sense that it acts as a means of exchange in international goods and asset trade, a store of value in international portfolios and official foreign exchange rate reserves, and a unit of account in international commodity pricing. BIS estimates of foreign exchange turnover show that the dollar is used as on side of about 90 percent of daily foreign exchange rate transactions. According to Eichengreen and Mathieson (2000), 60 percent of world foreign exchange reserves are held in US dollars\(^2\). Bekx (1998) estimates that over 50 percent of world exports in 1995 were denominated in US dollars, approximately four times the share of the US in total world exports. This predominance of the US dollar has been described by McKinnon (2001, 2002) as a world dollar standard. While the formation of the euro area has generated speculation about the stability of the current dollar role (e.g. Portes and Rey, 1998), at present there seems little evidence of significant change in the use of the dollar in trade and finance.

How does the special role of the US dollar influence monetary policy making in the US and the rest of the world? The quotation above suggests that the US has an advantage in policy making due to the fact that the rest of world holds dollars, and sets prices in dollars. Indeed many commentators argue that there is

\(^2\)This share has undoubtedly gone up since the advent of the euro, because all intra-European foreign reserves held in DM’s and other European currencies are no longer part of measured reserves.
an enormous welfare gain to the US from having its currency used so widely (e.g. Liu 2002). The literature on the international monetary system has developed a theory of ‘hegemonic stability’ based on the idea that the policies of one country play a central role in maintaining the smooth working of the international monetary system (Eichengreen 1995). According to this theory, US monetary policy may be determined without regard to international constraints, while monetary policy in the rest of the world must take account of US policies.

This paper examines the determination of optimal monetary policy in an asymmetric world economy, where the currency of one country (e.g. the US dollar) plays a predominant role in trade 3. While the evidence cited above illustrates the multidimensional role of an international currency, we focus on one particular aspect of this role - the importance of the currency in international export good pricing. We define a reference currency as one in which the prices of all world exports are preset. Many authors have noted (e.g. Goldberg and De Campa (2003)) that prices of imported goods sold in the US economy tend to be much less affected by exchange rate fluctuations than do imported good prices in non-US countries. This suggests that prices of a large fraction of exports to the US are pre-set in US dollar terms (which we refer to as local currency pricing, or LCP), and do not react quickly to movements of the exchange rate 4.

3In the recent international macroeconomics literature, considerable attention has been devoted to the determination of optimal monetary policy under sticky prices. See Benigno and Benigno (2003), Devereux and Engel (2003), Obstfeld and Rogoff (2002), among many other papers. But most of this literature is that it focuses on symmetric environments, where all countries are identical in economic structure.

4Bachetta and Van Wincoop (2002) and Kenen (2003) note that the US dollar is used as a invoice currency for the overwhelming majority of US imports, but for other OECD countries, imports are mainly invoiced in foreign currency.
However, exports to other countries may have their prices pre-set in the currency of the original producer (producer currency pricing, or PCP), and hence import prices are more sensitive to exchange rate movements. In this sense, the monetary policy problem will be asymmetric. The optimal monetary policy in the US will reflect the fact that there is little pass-through from exchange rates to prices of consumer goods in the US economy. On the other hand, for other countries, the optimal monetary policy will take account of high pass-through from exchange rates to prices.

How does the asymmetry in international export good pricing affect the optimal monetary policy outcome? We show that, at one level, the monetary policy context and outcomes implied by the model are quite closely in accord with popular wisdom about the position of the US in the world economy. In particular, the monetary authorities of the reference currency place a very low weight on exchange rate volatility in their monetary policy loss function. By contrast, the monetary authorities of the rest of the world will be much more concerned with exchange rate volatility. This seems to well approximate the observed indifference of the US to the exchange rate in monetary policy-making. A second feature of the outcome is that the reference currency country follows a more stable monetary policy than that of the rest of the world. More importantly though, we find that the monetary policy game between

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5In reality, there is considerable difference between the pass-through of exchange rate changes to import goods prices and final goods prices. In this paper, we abstract from this difference. In fact, the optimal monetary policy is more focused on the pass-through to final consumer goods. It would be possible to allow for a high rate of exchange rate pass-through into import good prices in combination with low pass-through into consumer good prices, without changing the results of the paper at all. This is shown in Devereux, Engel, and Tille (1999).

6In the model, the loss function is endogenously derived from the nature of the environment facing each country.
the reference currency country and the rest of the world has a key sense in which the reference country acts as a ‘hegemon’. A Nash equilibrium of this game is identical to one in which world monetary policy (for both countries) is determined by the preferences of the reference currency country alone. That is, the Nash equilibrium of the asymmetric game is the same as that which would obtain were the reference currency monetary authority to choose both its own and the rest of the world’s monetary rules to maximize its own welfare. In this sense, the asymmetry in international pricing gives the reference country a dominant role in international monetary policy determination. World monetary policy is designed according to its preferences, and, even if it could play a more explicitly dominant role (by acting as a ‘Stackelberg Leader’ in monetary policy determination), it would not wish to deviate from the Nash equilibrium.

For the rest of the world however, the outcome is quite different. In general their monetary authorities would wish to alter the determination of both their own and the reference country monetary rules, were they capable of playing a more dominant role. Despite this, there are no gains to international monetary policy coordination. Since the reference country enjoys the best possible outcome in a Nash equilibrium, any alternative monetary policy configuration chosen by a ‘world monetary authority’ is not incentive compatible, except in the trivial case where all the weight is given to reference country welfare.

Hence, our model supports the view that, under the dollar standard in international goods pricing, US monetary policy has a predominant role. A natural question to ask then is how much the US gains from this. How much better off are US residents due to the special place of the dollar in export price setting? The

\[\textsuperscript{7}\]Our model excludes some of the factors which would be important in the overall quantitative
surprising answer is that US residents are not better off, but rather are worse off. Expected utility for residents of the reference currency country, where pass-through from the exchange rate to the CPI is zero, is lower than that of the rest of the world, where there is full pass-through. While this may seem inconsistent with the result that the US determines world monetary policy, the explanation is that the asymmetric pricing means that the welfare outcomes are asymmetric. Even if monetary policy were determined by a world social planner with equal weights on both regions, welfare of the reference country would differ from that of the rest of the world.

Why does the dollar standard hurt the US? The reason is that when export pricing is done in terms of the US dollar, it prevents an efficient response of relative prices to underlying real shocks. An efficient monetary policy will generally want to employ both expenditure level (affecting total aggregate demand) and expenditure switching (affecting the relative demand for one country’s goods) effects. When import prices do not respond to the exchange rate, monetary policy cannot be used to generate expenditure switching effects. This has a welfare cost for the residents of the reference currency economy. Hence, in our model, the dollar standard is costly for the US economy.

Where does the special role of the reference currency come from? There is a considerable literature on the determinants of ‘international currency’. An early contribution by Krugman (1984) argues that there may be multiple equilibria due accounting of the gains from the dollar standard. In particular, there are no offshore holdings of currency in the model, so there is no seigniorage revenue earned on foreign money holdings. Nevertheless, we can do a welfare analysis by comparing expected utility in the reference currency country and in the rest of the world, because other than the special role of the reference currency, the model is otherwise symmetric.
to ‘snowballing effects’, whereby if one currency becomes the accepted standard, then all participants in international markets have an incentive to use this currency. On the other hand McKinnon (2003) argues that the special role of the U.S. dollar arose partly from the record of low inflation and stable monetary policy that the U.S. economy followed in the Post WWII period. In a later section of the paper, we extend the model to allow exporting firms the choice of currency in which to set prices, and investigate the conditions under which there is an equilibrium where exporters in both countries will use the currency of a single country for price setting.

Our results suggest that both the Krugman multiple equilibria explanation and the McKinnon policy-determined explanation are important elements in the selection of a reference currency. We show that, in the equilibrium of the monetary policy game, the reference currency country’s monetary authority will follow a more stable (lower variance) monetary policy. As a result, this tends to lock in an equilibrium where exporters in both countries use this currency in which to set prices. But the reason that the reference currency monetary authorities follow such a rule is precisely because the currency is used as a reference in international trade pricing. This implies however that there are other equilibria where either another currency will play the role of the reference currency, or no country’s currency does, so traded goods pricing is symmetric (either LCP or PCP) across countries.

The paper is structured as follows. The following section develops the main model, which is only a slight extension of Devereux and Engel (2003). Section 3 derives the solution of the model for given monetary policy rules. Section 4 derives the optimal rules in Nash equilibrium of a game between monetary authorities.

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8Although many other factors are likely to be important in the acceptability of an international currency, the choice of currency for pricing will remain one important channel.
Section 5 extends the model to allow for the endogenous choice of currency in which to set prices. Section 6 concludes.

2 The two country model

We construct a simple two-country model of trade and exchange rate determination. Firms set prices in advance, by assumption \(^9\). There is a continuum of home goods (and home population) and foreign goods (foreign population) of measure \(n\) and \((1 - n)\) respectively. Individual home (or foreign) goods are substitutable in preferences with elasticity \(\lambda\), but there is unit elasticity of substitution across the home and foreign categories of goods. The expected utility of home agents is

\[
E \left( \frac{C^{1-\rho}}{1-\rho} - \chi \ln \frac{M}{P} - \eta L \right)
\]

where \(C = n^{-n}(1-n)^{-(1-n)}C_h^{1-n}, C_h = \left(\int_0^n C_h(i)^{1-\lambda} di\right)^{1/1-\lambda},\) and \(\rho \geq 1\).

Here \(C\) is aggregate consumption, \(C_h\) is consumption of the home sub-aggregate, \(\frac{M}{P}\) are real money balances, with \(P = P_h^{n}P_{1-n}^{1-n}\) being the home CPI, and \(L\) is home labor supply. There is only a single period in which events take place \(^{10}\).

The structure of events within the period is as follows. First, before the period begins, households can trade in a full set of nominal state-contingent bonds. This

\(^9\)Since the model has been well covered in previous papers, here we will only briefly sketch out its main elements.

\(^{10}\)This may seem an extreme assumption, but in fact it is entirely innocuous, given the asset market structure. Extensions to an infinite horizon are quite trivial, and since there exists markets for risk-sharing across countries, this would leave all the results unchanged. Just so as to avoid time subscripts in the notation, we focus on a one-period problem.
means that households can offset any risk that is associated with monetary policy uncertainty, as well as risk due to country-specific productivity shocks (see below). The outcome of this stage is that households will enter the period with their revenue stream governed by an optimal risk sharing rule. Then the monetary authorities choose optimal monetary rules, given the optimal risk sharing rule, but taking into account the way in which firms set prices, as well as the distribution of country-specific technology shocks. Following this, firms set prices in advance, contingent on state-contingent discount factors, and the demand and marginal conditions that they anticipate will hold. After the realization of stochastic technology shocks, households choose their optimal consumption baskets, production and consumption takes place, and the exchange rate is determined.

Trade in state contingent nominal assets across countries will lead to the following optimal risk sharing arrangement:

\[ \Gamma P C^\rho = S P^* C^{*\rho}, \]  

(2.1)

where \( S \) is the nominal exchange rate, and \( P^* = P^*_h P^*_f (1-n) \) is the foreign price level \(^{11}\).

Optimal financial markets lead to the equalization of the marginal utility of money across countries, up to a state-invariant weighting \( \Gamma \). If the countries were entirely ex-ante identical, then obviously \( \Gamma \) would equal unity. But given the differences in pricing policies, countries are not necessarily the same, ex-ante. In this case, \( \Gamma \) will be chosen so as to reflect that different positions of the two countries in the initial competitive market in state contingent assets. Given the structure of

\(^{11}\)This condition says that optimal risk sharing will equate the marginal utilities of money across countries in each state of the world. The condition is a familiar one - see for instance Chari et al. (2002). For a rigorous proof of this condition, see Devereux and Engel (2003).
preferences, we can show that the value of $\Gamma$ will be
\[ \Gamma = \frac{E C^{(1-\rho)\rho}}{E C^{*\rho}}. \]  
(2.2)

In addition, household optimization gives rise to the money demand rules:
\[ M = \chi P C^\rho, \]  
(2.3)

and the implicit labor supply conditions given by
\[ W = \eta P C^\rho. \]  
(2.4)

Since monetary policy is determined after financial markets have closed, the monetary authorities take $\Gamma$ as given in their evaluation. We delay the discussion of optimal monetary rules until the next section.

Firms face demand for their good from consumers in both their domestic country and abroad. Firms have linear technologies, producing output from labor alone, but are subject to unpredictable (at the time of price setting) technology shocks in production. Firms can price-discriminate across national markets, and households have no ability to re-sell goods across countries. In addition, there is an asymmetric pricing structure. Home firms set prices for both the home market and the foreign market in terms of the home currency. But foreign firms set prices for export in terms of the home country currency. Hence, the foreign firms engage in LCP when selling abroad, whereas the home firms follow PCP. In this sense, the home currency is the ‘reference currency’ in all international trade, because all international traded goods have their prices set within this currency.

The Appendix outlines the details of the optimal pricing policies of firms. The following equations give the prices of the representative home and foreign firm for

\textsuperscript{12}For a proof, again see Devereux and Engel (2003), Appendix.
pricing of goods sold in home and foreign markets, respectively;

\[ P_{hh} = \hat{\lambda} \frac{E \left( \frac{WC^1}{\theta} \right)}{E(C^{1-\rho})} \]  
\[ P_{fh} = \hat{\lambda} \frac{E \left( \frac{W^*SC^1}{\theta^*} \right)}{E(C^{1-\rho})} \]  
\[ P_{hf} = \hat{\lambda} \frac{E \left( \frac{WC^{1-\rho}}{\theta} \right)}{E(C^{1-\rho})} \]  
\[ P_{ff}^* = \hat{\lambda} \frac{E \left( \frac{W^*C^{1-\rho}}{\theta^*} \right)}{E(C^{1-\rho})}. \]

In these equations, \( \hat{\lambda} \) represents the markup \( \frac{\lambda}{\lambda - 1} \), subscript \( h, f \) represents the price of the home good in the foreign market etc, and \( \theta \) represents the home country productivity coefficient. These equations indicate that optimal prices depend on the joint distribution of marginal cost \( \frac{W}{\theta} \), the exchange rate, and consumption (or aggregate demand). We assume that \( \theta \) can be represented as

\[ \theta = \exp(u), \]  

where \( u \) is mean zero and normally distributed. A similar assumption is made with respect to the foreign productivity shock.

An asterisk over the price means that the price is denominated in foreign currency. Hence, all home goods prices are denominated in home currency, while only foreign goods sold in foreign markets are denominated in the foreign currency. Given this convention, then the price indices for each country are as follows:

\[ P = P_{hh}^nP_{fh}^{1-n} \]  
\[ P^* = \left[ \frac{P_{hf}}{S} \right]^n P_{ff}^{1-n}. \]
The set of equations given by (2.1) and (2.2), in combination with (2.3) and (2.4) (with analogous conditions for the foreign economy), the pricing equations (2.5)-(2.8), and the price indices (2.10) and (2.11) give 12 equations that may be solved for the distribution of the variables $C, C^*, W, W^*, P, P^*, P_{hh}, P_{hf}, P_{fh}, P_{*f}, S$, and $\Gamma$.

3 Solving the Model

Because the model is log-linear and the underlying technology shocks are log-normal, we may solve for the exact distribution of all endogenous variables in closed form (the details are in the Appendix). The solution allows a dichotomy between variables that are determined in advance of the realization of technology shocks, i.e. $P_{hh}, P_{hf}, P_{fh}, P^*_{*f}$, and $\Gamma$, and variables determined after the shocks have occurred; i.e. $C, C^*, W, W^*$, and $S$.

The risk-sharing condition (2.1), in combination with the money demand equation (2.3) and the analogous condition for the foreign country implies a solution for the exchange rate:

$$S = \Gamma \frac{M}{M^*}. \quad (3.1)$$

Substituting this solution back into the money market clearing conditions then implies that

$$C = \left[ \frac{1}{\chi P_{hh} P_{fh}^{1-n}} \right]^{\frac{1}{\rho}} \quad (3.2)$$

$$C^* = \left[ \frac{1}{\chi P_{hf} P_{*f}^{1-n}} \right]^{\frac{1}{\rho}}. \quad (3.3)$$

This implies that home country consumption is independent of the realization of the foreign country money supply. This follows directly from the fact that the home country CPI is predetermined, given that both home goods and imported goods in
the home market have prices pre-set in home currency. But with full exchange rate pass-through into foreign imported goods, foreign country consumption is affected by home country monetary shocks.

In log terms, we may write these equations as

\[ s - E(s) = m - m^* \] (3.4)

\[ c - E(c) = \frac{1}{\rho} m \] (3.5)

\[ c^* - E(c^*) = \frac{1}{\rho} \left[ nm + (1 - n)m^* \right] \] (3.6)

where \( E \) denotes the mathematical expectation, and small-case letters denote logarithms.

Equations (3.4) and (3.6) can be solved for the variance of the exchange rate and consumption. But first we need to set out the monetary policy rules. We make the following assumption regarding the determination of monetary policies:

\[ m = m_0 + a_1 u + a_2 u^* \] (3.7)

\[ m^* = m_0^* + b_1 u + b_2 u^* \] (3.8)

Thus, the money supply is a log linear function of the shocks in each country, where the parameters of the rules, \( a_1, a_2, \) and \( b_1, b_2, \) have yet to be determined. These rules are perfectly general, because given that the model is log linear, and the shocks log-normal, the optimal form of monetary rules must be log-linear.

Monetary policy will be chosen to maximize expected utility for each country. In order to evaluate expected utility, it is necessary to determine expected consumption and employment. These will be affected by the stochastic structure of the model, given ex-ante optimal price setting. Using (2.5)- (2.8), along with the labor supply
equations, and the risk sharing condition (2.1), we may set out the following two conditions which implicitly determine the mean values of $C$ and $C^*$.

\begin{align}
1 &= \hat{\lambda} \eta \Gamma_c^{1-n} \frac{[E(C_c^\theta)]^n [E(C_c^\theta)]^{1-n}}{E(C^\rho)} \\
1 &= \hat{\lambda} \eta \Gamma_c^{-n} \frac{[E(C_c^\theta^* C_c^\theta^* \Gamma_c^1)]^n [E(C_c^\theta^* C_c^\theta^* \Gamma_c^1)]^{1-n}}{E(C_c^\rho^* C_c^\rho^*)}
\end{align}

(3.9) (3.10)

Using the properties of the log-normal distribution, we may re-write equations (3.9) and (3.10) in terms of the mean and variances of log consumption and exchange rates. This gives

\begin{align}
E(c) &= -\frac{1}{\rho} \ln(\Gamma_c^{1-n}) - \frac{2 - \rho}{2} \sigma_c^2 - \frac{n \sigma_u^2 + (1 - n) \sigma_u^2}{2\rho} + \frac{n \sigma_c u + (1 - n) \sigma_c u^*}{\rho} \\
E(c^*) &= -\frac{1}{\rho} \ln(\Gamma_c^{-n}) - \frac{2 - \rho}{2} \sigma_c^2 - \frac{n(1 - n)}{2\rho} \sigma_u^2 + \frac{n \sigma_u^2 + (1 - n) \sigma_u^2}{2\rho} + \frac{n \sigma_c u + (1 - n) \sigma_c u^*}{\rho} + \frac{n(1 - n) (\sigma_u - \sigma_u^*)}{\rho}
\end{align}

(3.11) (3.12)

Mean (log) consumption of the home country is determined only by home consumption variance, the variance of technology shocks, and the covariance of consumption with technology shocks. Equations (3.5) and (3.11) imply that both the mean and variance of home consumption is independent of foreign monetary policy. On the other hand, mean consumption of the foreign country depends both on consumption variance, the covariance of consumption with technology, and on exchange rate variance and covariance with technology shocks. Why is it that exchange rate volatility affects expected foreign consumption, but not home consumption? This is because exchange rate volatility affects foreign import prices, and through this, the average level of pre-set prices. It will therefore affect mean consumption in the
foreign country. Note that from (3.6) and (3.12), foreign consumption will clearly be influenced by both home and foreign monetary policy rules.

Since mean consumption depends on the variance and covariance properties of consumption and the exchange rate, we can derive a welfare measure for policy makers solely based on these second moments. Assume that monetary authorities in each country are concerned with the expected utility of consumption and dis-utility of labor supply, but ignore the utility of real money balances. Therefore, the home country monetary authority chooses its monetary rules to maximize

$$E\left(\frac{C^{1-\rho}}{1-\rho} - \eta L\right).$$

(3.13)

From the properties of the price setting equations in the home and foreign countries, and the labor market clearing condition, we can establish that

$$E(L) = \frac{n}{\lambda \eta} E(C^{1-\rho}) + \frac{1-n}{\lambda \eta} E(C^{*1-\rho}) \Gamma$$

(3.14)

Combining (3.13) and (3.14), we may write expected home country utility as

$$E(U) = \frac{\lambda - n(\lambda - 1)(1-\rho)}{(1-\rho)\lambda} E(C^{1-\rho}) - \frac{(1-n)(\lambda - 1)}{\lambda} \Gamma E(C^{*1-\rho})$$

(3.15)

Since the log-normal distribution satisfies $E(C^{1-\rho}) = \exp\left\{(1-\rho)[E(c) + \frac{1-\rho}{2} \sigma_c^2]\right\}$, (3.15) ultimately depends only on the second moments of consumption and the exchange rate. These in turn depend on the monetary rules (3.7)-(3.8).

**Flexible Price Equilibrium**

It is useful to show the allocation that would obtain in an economy with fully flexible prices. If all prices could respond to the ex post value of technology shocks,

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13Obstfeld and Rogoff (2000) give a justification for this assumption.
then money would be neutral. The asymmetry in pricing would be irrelevant, because from (2.5)-(2.8), with ex-post price setting, the law of one price would hold across markets. Consumption and employment would be equalized across countries. The expressions for consumption and employment in the flexible price equilibrium are:

\[
C = C^* = (\hat{\lambda} \eta)^{-\frac{1}{\rho}} (\theta^a \theta^{1-n})^{\frac{1}{\rho}}. \tag{3.16}
\]

\[
L = L^* = (\hat{\lambda} \eta)^{-\frac{1}{\rho}} (\theta^a \theta^{1-n})^{\frac{1}{1-\rho}}. \tag{3.17}
\]

Productivity shocks affect consumption in each country in proportion to country size, and reduce (increase) employment in each country as \( \rho > 1 \) (\( \rho < 1 \)).

4 Optimal Monetary Policy

We now examine the optimal monetary rules chosen by independent monetary authorities in each country. Monetary policy is chosen with commitment, in the sense that monetary authorities choose the parameters of a monetary rule to maximize expected utility of the domestic agent, taking into account the way in which prices are set.

A natural objective of the monetary authorities would be to design optimal monetary policy so that the economy replicates the flexible price allocation \(^{14}\). But

\(^{14}\)While we might anticipate that there would also be a strategic externality by which each country would attempt to use monetary policy to improve its terms of trade vis a vis the other country, this does not arise here because monetary rules are determined \textit{ex-ante}, before private sector prices have been set. The strategic externality by which monetary policy may improve one country’s welfare by influencing the terms of trade can only be effective for a \textit{surprise} monetary shock, taking private sector expectations (i.e. prices) as given. For the same reason, there is no incentive to pursue inflation surprises in this model, because the monetary authorities follow rules
given the way in which prices are set, this is not possible. We show this in the following proposition.

Proposition 1 *No feasible monetary rule can replicate the flexible price world allocation.*

Proof: From (3.16) and (3.17), in order to achieve the flexible price response of consumption, the home country must follow a monetary rule in which \( a_1 = n \) and \( a_2 = 1 - n \). But if the home country follows this rule, then the foreign country must follow the same rule, if it wishes to achieve the flexible price response of foreign consumption (see (3.6)). But in this case, neither country achieves the flexible price equilibrium response of employment. To see this, note that employment is determined by

\[
\theta L = n \frac{P}{P_{hh}} C + (1 - n) \frac{SP^*}{P_{hf}} C^*
\]

(4.1)

When the two countries monetary rules follow the conjectured policy, the exchange rate (3.4) is constant. Then the right hand side of (4.1) is proportional to \((\theta^n \theta^{1-n})^{\frac{1}{2}}\). But then \( L \) cannot satisfy (3.17). An equivalent argument holds for \( L^* \).

Monetary authorities choose their optimal rules to maximize expected utility, taking into account the determination of prices, consumption, employment, and exchange rates, but taking as given the coefficient of optimal risk-sharing \( \Gamma \). In order to define an equilibrium of the monetary policy game between countries, it is

\[\text{with commitment. These issues are discussed in Obstfeld and Rogoff (2002).}\]

\[\text{An alternative possibility is to have monetary policy rules chosen before the ex ante asset market trading. We did solve the model in that case. Although the actual form of the solutions are altered, the qualitative results (in particular the asymmetries) do not differ from those presented below.}\]
convenient to reformulate the objective functions (3.15) in the following way. Define expected utility in the home country as:

$$EU(a, b) = \phi_n \Gamma \frac{\rho^{-1}}{\rho} X - \frac{(1-n)}{\lambda} \Gamma X^*$$  \hspace{1cm} (4.2)

Likewise, expected utility for the foreign country monetary authority is

$$EU^*(a, b) = \phi_{1-n} X^* - \frac{n}{\lambda} \Gamma \frac{\rho^{-1}}{\rho} X$$  \hspace{1cm} (4.3)

where $X$ and $X^*$ are defined as

$$X = \Theta \exp[(1-\rho)(-\frac{1}{2}\sigma^2_c - \frac{\tilde{\sigma}^2_u}{2\rho} + \frac{\sigma_{cu}}{\rho})]$$  \hspace{1cm} (4.4)

$$X^* = \Theta \exp[(1-\rho)(-\frac{1}{2}\sigma^2_c - \frac{n(1-n)}{2\rho}\sigma^2_s - \frac{\tilde{\sigma}^2_u}{2\rho} + \frac{\sigma_{c^*u}}{\rho} + n(1-n)(\frac{\sigma_{su} - \sigma_{su^*}}{\rho})]$$  \hspace{1cm} (4.5)

$\phi_n$, $\phi_{1-n}$, and $\Theta$ are constant functions of parameters$^{16}$, and $\tilde{\sigma}^2_u = n\sigma^2_u + (1-n)\sigma^2_{u^*}$, $\sigma_{cu} = n\sigma_{cu} + (1-n)\sigma_{cu^*}$, $\sigma_{c^*u} = n\sigma_{c^*u} + (1-n)\sigma_{c^*u^*}$.

Although home consumption is independent of the foreign monetary rule (shown above), its welfare does depend on the foreign monetary rule, because expected home country employment is affected by foreign monetary policy. Thus, the home country is not indifferent to the rule followed by the foreign monetary authority.

A special case of (4.2) and (4.3) arises when $\rho = 1$. Then expected employment is constant in both countries (see (3.14)). Therefore, the monetary authorities are concerned solely with maximizing expected utility of their own consumption. For the home country, this is equivalent to using monetary rules to maximize:

$$(-\frac{1}{2}\sigma^2_c - \frac{\tilde{\sigma}^2_u}{2} + \sigma_{cu}).$$  \hspace{1cm} (4.6)

$^{16}$In particular, $\phi_n = \frac{1}{1-\rho} - \frac{\tilde{\sigma}^2_u}{\lambda}$, $\phi_{1-n} = \frac{1}{1-\rho} - \frac{1-n}{\lambda}$, and $\Theta = \exp \left[ \frac{(\rho^{-1})}{\rho} \ln(\hat{\lambda}\eta) \right]$
By contrast, for the foreign country, in the case $\rho = 1$, the relevant objective function is

$$(-\frac{1}{2}\sigma^2_{c^*} - \frac{n(1-n)}{2}\sigma^2_s - \frac{\tilde{\sigma}^2_u}{2} + \sigma_{c^*u} + n(1-n)(\sigma_{su} - \sigma_{su^*})). \quad (4.7)$$

Then home utility depends (negatively) on consumption variance, but is increasing in the covariance of consumption and productivity shocks. An optimal monetary rule will trade off these costs and benefits, making consumption positively co-vary with $u$ and $u^*$. Because there is no pass-through into the home economy, its monetary authority is indifferent to exchange rate variance.

For the foreign country, exchange rate variance does have welfare consequences. Exchange rate variance reduces foreign utility \(^{17}\). But positive covariance of the exchange rate and home productivity shocks, or a negative covariance with foreign productivity, raises foreign utility \(^{18}\). An optimal monetary rule for the foreign country therefore has to take account of effects on both consumption and the exchange rate.

**Proposition 2** When $\rho = 1$, the home country is indifferent to exchange rate volatility, while the foreign country places a negative weight on exchange rate volatility.

**Proof:** see above discussion

---

\(^{17}\)This occurs because exchange rate variance raises the mean foreign price level, for any expected value of the money stock, and hence reduces expected foreign consumption.

\(^{18}\)The intuition behind this is that the exchange rate generates an expenditure switching effect in the foreign economy. A positive home (foreign) technology shock requires a depreciation (appreciation) in the exchange rate in order to increase foreign country demand for home (foreign) goods. The equivalent channel does not work in the home country, because there is no expenditure switching at the consumer level.
In the more general case with $\rho > 1$, the home country is no longer completely indifferent to exchange rate variability. But for all reasonable parameter values and shock distributions, the home country places less weight on exchange rate variability than does the foreign country. Table 2 illustrates the impact of exchange rate volatility on expected utility, for each country, for various values of $\rho$, and a given calibration of other parameters. In all cases, the home country is less affected by movements in exchange rate variance.

A Nash equilibrium in the monetary game between countries is defined in the standard way, as the pair $a^n, b^n$ which solves:

$$\max_a EU(a, b^n)$$ (4.8)

$$\max_b EU^*(a^n, b)$$ (4.9)

The simple form of the model in fact allows us to solve for the exact solutions to the monetary policy rules. By observing (4.2) and (4.3), we notice an important asymmetry in the monetary policy game. The home country rules $a_1, a_2$ affect the composite expression $X^*$, defined above, but the foreign country monetary rules $b_1, b_2$, do not affect $X$. Moreover, note that $X^*$ enters linearly, with a negative sign, in both the home and foreign country’s objective functions. Hence, in choosing its monetary rules, the foreign monetary authority indirectly chooses to maximize home expected utility.

The first order conditions characterizing the Nash equilibrium can be written as (for both $a_1, a_2$ and $b_1, b_2$ respectively):

$$\phi_n \Gamma^{-\frac{1}{\rho}} \frac{\partial X}{\partial a} = \frac{(1 - n) \partial X^*}{\lambda}$$ (4.10)

$$\frac{\partial X^*}{\partial b} = 0$$ (4.11)
Using the property of optimal risk sharing from equation (2.1), we may establish that
\[
\Gamma = \frac{EC^{1-\rho}}{EC^{*}(1-\rho)} = \Gamma \frac{\hat{\lambda}}{X^*} = \left(\frac{X}{X^*}\right)^\rho. \tag{4.12}
\]
where the second equality follows from the definition of $X$ and $X^*$. Now substituting into the first order conditions (4.10) and (4.11), we arrive at the characterization of the optimal monetary reaction functions for each country:

\[
\delta a_1 = n \left\{ \hat{\lambda} - (1 - \rho) [n + (1 - n)[n + \rho(1 - n)]] \right\} + n[(1 - n)(1 - \rho)]^2 b_1 \tag{4.13}
\]

\[
\delta a_2 = (1 - n)[\hat{\lambda} - n(1 - \rho)] + n[(1 - n)(1 - \rho)]^2 (b_2 - 1) \tag{4.14}
\]

\[
b_1 = \frac{n(\rho - 1)}{\rho n + (1 - n)} (a_1 - 1) \tag{4.15}
\]

\[
b_2 = \frac{n(\rho - 1)(a_2 + 1) + 1}{\rho n + (1 - n)} \tag{4.16}
\]

where
\[
\delta = \hat{\lambda} - n(1 - \rho) \left\{ 1 + (1 - n)[\rho(1 - n) + n] \right\} \tag{4.17}
\]

Equations (4.13) and (4.14) describe the home country’s first order conditions, while (4.15) and (4.16) describe the foreign country’s conditions. The solution to (4.13)-(4.16) is a Nash equilibrium in the monetary rules.

Table 1 describes the solution. From the table, we may establish that a) $n \leq a_1 < 1$, 0 < $a_2 \leq (1 - n)$, b) $b_1 \leq 0$, $b_2 \geq 1$, and c) $a_1 + a_2 = 1$, $b_1 + b_2 = 1$.

In the special case with $\rho = 1$, we have $a_1 = n, a_2 = 1 - n$, and $b_1 = 0, b_2 = 1$. Thus, the home country adjusts monetary policy to both the home and foreign shocks according to their weight in world GDP, and the foreign country focuses only on its own domestic shock.

Note that in this case, given our assumption that $u$ and $u^*$ are i.i.d., it follows the home country monetary variance is lower than that of the foreign country. In
addition we note that the variance of the exchange rate is lower than would occur were there to be no world reference currency. Given the Nash equilibrium described above, exchange rate variance is $2n^2\sigma_u^2$. It is easy to show that, if exchange rate pass-through into both home and foreign countries was complete, then the Nash equilibrium would be $a_1 = 1, a_2 = 0$, and $b_1 = 0, b_2 = 1$. In that case, exchange rate variance would be $2\sigma_u^2$.

Table 1 shows the solution for $a_1, a_2$ and $b_1, b_2$ in the more general case where $\rho > 1$. Figure 1 and Figure 2 illustrate the reaction curves, for the responses to both shocks. Each is upward sloping. The same general properties of the solution described above still apply.

We now focus on the welfare outcomes of the monetary policy game. Using the solutions of Table 1, and the description of the Nash equilibrium, we now state the following proposition:

**Proposition 3** A Nash equilibrium is identical to an outcome where the home economy determines world monetary policy rules.

The proposition says that a Nash equilibrium is asymmetric, in the sense that it gives the same allocation as if the home economy was choosing both its own and the foreign economy’s monetary rules. Equivalently, in the Nash equilibrium, the foreign economy indirectly maximizes expected home country utility as well as its own utility.

The proof of the proposition is straightforward. From the objective function (4.2), note that $X$ is independent of $b_1$ and $b_2$, and home expected utility is linear in $X^*$. Since, in a Nash equilibrium, the foreign monetary authority chooses $b_1$ and $b_2$ to maximize a linear function of $X^*$, it’s choice is also the optimal choice of $b_1$ and $b_2$ for the home economy.
Note that the proposition specifically does not hold in the reverse direction. The Nash allocations for $a_1$ and $a_2$ do not maximize foreign country welfare. Hence, the foreign country experiences negative welfare externalities in a Nash equilibrium.

The key ingredient in this asymmetry is that home consumption is independent of foreign monetary rules. As a result, the foreign monetary policy influences home utility only to the extent that it influences expected employment in the home country. Since the monetary rules $b_1$ and $b_2$ that maximize foreign utility are identical to those which minimize expected home employment, these rules are then the optimal rules from both the home and foreign country perspective.

This also means that the monetary rules governing the world economy are identical to those that would hold were the home country a ‘Stackelberg Leader’, choosing its monetary policy in advance, taking account of the reaction of the foreign country.

Figures 1 and 2 illustrate the equilibrium in terms of the reaction curves (4.13)-(4.16) for both $a_1, b_1$ and $a_2, b_2$, respectively. For $\rho > 1$, the homecountry’s reaction curve slopes upward in both Figures . The foreign country’s reaction curve is also upward sloping, and steeper than that of the home country. Point N represents the Nash equilibrium. Since N is a global optimum for the home country, its iso-utility lines can be illustrated as converging to a maximum at N. For the foreign economy, point F represents the global optimum, equivalent to the allocation that would obtain if the foreign monetary authority could choose both home and foreign monetary policy rules. The foreign iso-utility lines converge to a maximum at F. Utility of the foreign country at N is less than at F.

In Figure 1, relative to the Nash equilibrium, the foreign country would like to increase $b_1$ towards zero, and increase $a_1$. Hence, it would like the home country to react more to its own shock, and for itself to react less (in absolute terms) to
the home shock. If the foreign economy could act as a Stackelberg leader, it would choose point S.

Figure 2 illustrates the determination of $a_2, b_2$. Again, the points N and F represent the global optimal allocations for the home and foreign country respectively, with the first being the Nash equilibrium. If the foreign economy could act as a Stackelberg leader, it would reduce the weight placed on its own productivity shock in its monetary rule, which would have the effect of reducing the home country $a_2$ coefficient.

A corollary of the proposition is that there is no gain from international monetary policy coordination, except in the trivial case where the social welfare function used for coordination places all weight on the home economy welfare. The Nash equilibrium is therefore efficient. While the foreign economy could gain from an allocation chosen by an equal weighting world monetary authority, the home economy would lose. In Figures 1 and 2 we could illustrate a contract curve, or set of efficient monetary coefficients, indexed by different weights on home and foreign welfare in evaluating the world optimum. The Nash equilibrium is at one end of this curve, where the weight on home utility is one.

This equilibrium of the monetary policy game has many features that seem to resemble the description of US monetary policy under the de facto world ‘dollar standard’. It is widely acknowledged that the US pays little attention to the exchange rate in its monetary policy. But compared to many other countries, the US follows a more stable path of monetary policy. More importantly, the US does have an advantage over the rest of the world in setting monetary policy, due to the special role of the dollar. In our model, this advantage is quite extreme in the sense that world monetary policy completely reflects US preferences. The situa-
tion has some parallels in the historical literature on ‘Hegemonic Stability’ of the International Monetary System (see Eichengreen (1995) for instance). While this theory was specifically designed to interpret the stability of fixed exchange rate systems, in this model, the US acts as a hegemon, but within a decentralized world Nash equilibrium with flexible exchange rates. But just as in the traditional theory, our model predicts that the hegemon has no interest in international consultation in monetary policy making, and would not support a move towards international monetary cooperation.

Much popular discussion of the role of the US dollar in the world economy goes even further than this. It is frequently asserted that US residents gain from the role of the US dollar as the international reference currency. There is a wide range of popular explanations for how these gains might come about - some argue that the role of dollar allows the US to run current account deficits without limit, that it gives it the ability to dictate world monetary policy, or that it allows it to dominate the world oil market. By contrast, most economists (e.g. Krugman 1999) estimate that the gains that the US gets from the dominance of the dollar are modest, mainly accounted for by seigniorage revenue on offshore dollar holdings, and are a very small percentage of total US fiscal revenue.

We now address the question of the welfare gains to a reference currency. In our model, there are no offshore currency holdings, so the primary source of benefit is not present. But the fact that the outcome of the monetary policy game is asymmetric means that welfare levels are different for the home and foreign countries. Since the rest of the model is perfectly symmetric, the difference in welfare gives an exact measure of the gains from having an international currency.

It might be thought that this question has already been answered by Proposition
2. The role of the reference currency leads the home country to be placed on one end of the utility contract curve. It would then seem that the reference currency country is always better off. But this conclusion is incorrect. Since the game itself is asymmetric, welfare levels would differ even if each country’s preference were given equal weight in world monetary policy making. In order to assess the gains to having a dominant currency, we must compare levels of expected utility between the home and foreign countries.

This comparison gives a surprising result.

**Proposition 4** In a Nash equilibrium, expected utility for the home country is always lower than that of the foreign country.

Proof: See appendix.

Although the home country’s preferences dominate world monetary policy making, home country residents are actually worse off than those of the foreign country, in the equilibrium of the monetary policy game. The ownership of an international reference currency bestows costs rather than benefits - residents of the reference country have lower expected utility.

Although the result may seem surprising, the explanation is quite intuitive. The absence of exchange rate pass-through into the home economy inhibits the usefulness of monetary policy. As is described above, an ideal monetary policy rule is one which achieves both expenditure level effects and expenditure switching effects. The foreign country can use both channels in designing a monetary rule, because the exchange rate affects relative prices. The home country can’t do this - since the exchange rate does not affect the demand for home goods relative to foreign goods, monetary policy can affect only the level of spending. Given the absence of pass-through into
the home economy, home output is not adjusted efficiently to home and foreign technology shocks. As a result, expected utility is lower than that of the foreign country, where output can be affected by the exchange rate.

5 Endogenous Currency Pricing

So far it has just been assumed that the home currency is used as a reference for international pricing. In principle, this decision should be endogenous. The set of forces leading to the adoption of an international ‘vehicle’ currency have been discussed extensively in the literature on international monetary economics (see Matsuyama et al. (1991) McKinnon (2002), Krugman (1984), Rey (2001)). Many factors, such as economic size, history, capital flows, and economic policy may be part of the explanation. Moreover, the presence of ‘network externalities’ in the choice of standard may give rise to multiple equilibria. Krugman (1984) notes that while economic size is likely to be an important factor, there may also be ‘snowballing’ effect, whereby even if countries are of similar size, if one currency becomes acceptable in exchange then all countries will have an incentive to support this outcome. This suggests that the US dollar standard may be due to historical accident as much as current fundamentals. McKinnon (2002) takes a different view however. He stresses the importance of US monetary policy, arguing that the US dollar’s role as a world currency resulted from low and stable US inflation rates in the post-WWII international system.

In this section, we present a brief analysis of the determination of the reference

\textsuperscript{19}Economic size does not play any significant role in our model, because a) there are no non-traded goods, so all countries are fully open, and b) each country produces a measure of goods equal to its population, so the terms of trade is independent of size.
currency for international trade. We illustrate the sense in which the asymmetric
pricing outcome examined in the previous section can be an equilibrium of the model
where the currency of pricing is endogenous\textsuperscript{20}.

We assume that firms can choose which currency they would like to set their
price in. They do this taking into account that whatever their choice, they will
then choose a nominal price to maximize expected discounted profits. In addition
to this however, the firm incurs a cost of adjusting prices, ex-post. We assume
that these costs arise only when the price facing consumers is adjusted. We might
think of these as menu-changing costs, or customer resistance costs, that require
management services on the part of the firm. If the firm sets the price in the local
currency of the buyer, it will never face these costs, as the price will be independent
of the state of the world. But if the price is set in the exporting firms own currency,
prices facing the foreign consumer will be dependent upon the exchange rate. We
handle this in the following simple way. Assume that if the firm sets prices in the
consumers currency (LCP), then it faces no additional cost. But if it sets prices in
its own currency, then it faces a fixed (nominal) cost given by $\delta$. This is thought
of as a cost of ex-post adjustment that comes from the exchange rate pass-through
into the importing countries CPI. The presence this fixed cost per se will therefore
encourage the firm to set prices in the currency of the consumer (LCP).

On the other hand, the level of expected (discounted) profits, gross of fixed costs,

\textsuperscript{20}Our analysis doubtless omits many important factors that determine the role of an international
currency, but highlights one potentially important factor, within the context of this model.

\textsuperscript{21}We think of this being part of the technology. That is, there is a technology whereby firms
who wish to set export prices in their own domestic currency must pay incur a fixed management
cost $\delta$. Competitive ‘managerial’ firms provide this management services by combining home and
foreign varieties in the same manner that consumers do.
will depend upon whether prices are preset in the producers currency or consumers currency. Using the same demand and cost structure from the model set out above, we may define the expected discounted profits on foreign sales for a home firm that sets its export price in terms of its own currency (PCP) as

$$E[d\pi^{PCP}(i)] = E[d(P_{hf}(i) - \frac{W}{\theta})X^{PCP}_h(i)]$$  \hspace{1cm} (5.1)

where $X^{PCP}_h(i) = (\frac{P_{hf}(i)}{S_{hf}})^{-\lambda} \frac{P^*_h}{P^*_f} C^*$.

If the firm chooses alternatively to set its price in terms of foreign currency (LCP), it faces expected discounted profits given by

$$E[d\pi^{LCP}(i)] = E[d(SP^*_h(i) - \frac{W}{\theta})X^{LCP}_h(i)]$$  \hspace{1cm} (5.2)

where $X^{LCP}_h(i) = (\frac{P^*_hf(i)}{P^*_h})^{-\lambda} \frac{P^*_h}{P^*_f} C^*$.

The Home country firm will set its price in its own currency if the expected profit differential from doing so exceeds the expected menu cost. Thus it follows PCP whenever

$$E[d\pi^{PCP}(i)] - E[d\pi^{LCP}(i)] > \delta$$  \hspace{1cm} (5.3)

The sequence of actions within a period is now described as follows. First, firms choose the currency in which prices are set. Following this, the monetary authorities in each country choose their optimal rules. Then firms choose the actual prices of goods. Finally, the technology shocks are realized, and consumption, output and exchange rates are determined.

In Devereux, Engel and Storgaard (2003), it is shown that the left hand side of (5.3) may be approximated by the following

$$\bar{\pi} \lambda (\lambda - 1) \left[ \frac{Var(\ln S)}{2} - Cov(\ln \frac{W}{\theta}, \ln S) \right]$$  \hspace{1cm} (5.4)
where \( \bar{d} \) and \( \bar{\pi} \) denote the discount factor and profits in a deterministic economy. The intuition behind this condition is straightforward. Since profits are convex (linear) in the exchange rate when the firm following PCP (LCP), a higher exchange rate variance will encourage the firm to follow PCP. But if the covariance of the exchange rate and marginal cost \( \frac{W}{\theta} \) is positive, expected costs will be higher under PCP. If the right hand side of (5.4) is positive, the firm would wish to set prices in its own currency (PCP), in the absence of menu costs of price change. Thus, the condition (5.3) becomes

\[
\lambda(\lambda - 1) \left[ \frac{\text{Var}(\ln S)}{2} - \text{Cov}(\ln \frac{W}{\theta}, \ln S) \right] > \frac{\delta}{\bar{d} \bar{\pi}} \tag{5.5}
\]

The equivalent condition for the foreign firm is

\[
\lambda(\lambda - 1) \left[ \frac{\text{Var}(\ln S)}{2} + \text{Cov}(\ln \frac{W^*}{\theta^*}, \ln S) \right] > \frac{\delta}{\bar{d} \bar{\pi}}, \tag{5.6}
\]

where, to maintain symmetry, we assume that the fixed cost facing the foreign firm is identical to that of the home firm.

If condition (5.5) (condition (5.6)) is not satisfied, then the home firm (foreign firm) will instead set prices according to LCP. From these conditions, we can establish the following proposition.

**Proposition 5** There exists a positive menu cost \( \bar{\delta} \) such that all home firms follow PCP, and all foreign firms follow LCP.

*Proof:* See Appendix.

The proposition says that there exists a value \( \bar{\delta} \) such that the asymmetric pricing structure outlined in the previous section is an equilibrium. In this equilibrium, the home firm will choose PCP, while the foreign firm will choose LCP. Following
this, the monetary authorities choose their optimal rules in exactly the same way described in the previous section. The key intuition is that the way in which the monetary rules are set acts so as to lock in the asymmetric pricing policies of home and foreign firms. In an equilibrium of the monetary policy game outlined in section 4, the home country’s monetary policy rule tends to target both home and foreign productivity shocks. Since these are independent of each other, the home country’s money supply is less volatile than that of the foreign country. As a result, 

\[ \text{Cov} (\ln W_\theta, \ln S) \] is less than \(-\text{Cov} (\ln W^{*}_{\theta}, \ln S)\), because in the simple form of the model, the variability of the wage rate is completely determined by the variance of the domestic money stock. Thus, for relatively small menu costs of price change, it is more likely that the home firm will wish to set its price in its own currency, while the foreign firm will wish to set its price in the home currency. This is a variant of the result of Devereux, Engel, and Storgaard (2003), which shows that firms would wish to set their export prices in the currency of the country which had the lowest variance of money growth.

While the proposition establishes that the outcome of the previous section is an equilibrium of a game in which firms choose the currency of pricing, in general there will be other equilibria of this game. For instance, if all firms choose LCP, then from the results of Devereux and Engel (2003), and Devereux, Engel and Storgaard (2003), the optimal monetary rules chosen by home and foreign countries will in fact support global LCP as an outcome. Likewise, because the model is entirely symmetric, if proposition 2 holds, then there must be an alternative equilibrium where, if foreign firms follow PCP, and home firms choose LCP, this is supported as an equilibrium in the monetary policy game.

These results suggest that both the Krugman (1984) multiple equilibrium hy-
ypothesis, and the McKinnon (2002) fundamentals hypothesis, may be part of the explanation for the dollar standard. Given the presence of asymmetric pricing, the endogenous decisions of monetary authorities respond in a certain way so as to confirm the pricing decisions of firms. Nevertheless, there may be other equilibria which would also be self-confirming in the sense that they would induce different monetary policy rules.

6 Conclusions

An almost universal characteristic of the international monetary system is the role of a dominant currency. In the classical theory of ‘hegemonic stability’, the economic policies of the dominant currency determine the stability of the international system, typically by adherence to the ‘rules of the game’ in a fixed exchange rate system. But in the decades since floating exchange rates, the US dollar has remained a preeminent currency in international trade and finance - leading to a de facto dollar standard. This paper has extended the recent literature on monetary policy in sticky-price general equilibrium models to allow for such a dollar standard. We found that the equilibrium has many of the attributes of popular discussion of the predominance of US monetary policy in the world economy. In particular, a decentralized world of floating exchange rates acts so as to maximize the welfare of the US. But, in sharp contrast to popular discussion, we found that this situation brings no net benefits to the US, when compared to welfare of the rest of the world. US residents are worse off in the situation of having a dollar standard, compared to residents of the rest of the world.
References


**APPENDIX**

**A  Optimal pricing setting**

The optimization problem of each firm is to maximize the discounted expected profits, taking the individual demand function as given. Home firms set both the domestic price and export price in the currency of the producer (PCP). The home firm $i$’s problem is then:

$$
\max_{P_{hh}, P_{hf}} E[d\pi(i)] = \max_{P_{hh}, P_{hf}} E[d((P_{hh}(i) - \frac{W}{\theta})X_h(i) + (P_{hf}(i) - \frac{W}{\theta})X^*_h(i))] \quad (A.1)
$$

Where $d = PC^{-\rho}$ is the stochastic discount factor, $X_h(i) = nC_h(i)$ is the total sales of firm $i$ to home residents and $X^*_h(i) = (1 - n)C^*_h(i)$ is the total sales to foreign residents.

Foreign firms set both the domestic and the export price in the currency of the consumer (LCP). The foreign firm $i$’s problems is:

$$
\max_{P_{fh}, P^*_ff} E[d^*\pi^*(i)] = \max_{P_{fh}, P^*_ff} E[d^*((\frac{P_{fh}(i)}{S} - \frac{W^*}{\theta^*})X_f(i) + (P^*_ff(i) - \frac{W^*}{\theta^*})X^*_f(i))] \quad (A.2)
$$

Substitute the risk-sharing condition 2.1, the labor supply function 2.4 and its foreign equivalent into the first order conditions derived from home and foreign firms’ optimization problem, we can derive the optimal pricing policies of firms (2.5-2.8).

**B  Model solution**

**Solving for $Ec$**  From the price index (2.10) and pricing equations (2.5) and (2.6), we have

$$
P_{hh}^nP_{fh}^{1-n} = \lambda \frac{E(WC^{1-\rho})^n[E(W^*SC^{1-\rho})]^{1-n}}{E(C^{1-\rho})} \quad (B.3)
$$
Using the risk-sharing condition 2.1 and 2.4 and its foreign equivalent, taking out the predetermined terms, we have (3.9) of the paper:

\[ 1 = \hat{\lambda} \eta \Gamma^{1-n} \frac{E(C_{\theta})^n}{E(C^{1-\rho})} \frac{E(C_{\theta}^*)^{1-n}}{E(C^{1-\rho})} \]

Now using the fact that the solution for consumption and exchange rate will be log-normal, and taking logs, we may get the expected consumption (3.11):

\[ Ec = -\frac{1}{\rho} \ln(\hat{\lambda} \eta \Gamma^{1-n}) - \frac{2 - \rho}{2} \sigma_c^2 - \frac{2n(1-n)(1-\rho)\sigma_u^2}{2\rho} + \frac{n \sigma_u + (1-n)\sigma_{u^*}}{\rho} \]

Similarly, we can derive the equation (3.10) and (3.12).

**Solving for \( EL \) and \( EU \)**  
Home goods market clearing condition implies

\[ \theta L = n \frac{P C}{P_{hh}} + (1 - n) \frac{P^* C^*}{P_{h^*}} \]

Substituting the pricing equations (2.5) and (2.7) into (B.4), we get

\[ L = n \frac{PC}{\theta} \frac{E(C^{1-\rho})}{\hat{\lambda} E(WC^{1-\rho})} + (1 - n) \frac{SP^* C^*}{\theta} \frac{E(C^{1-\rho})}{\hat{\lambda} E(WC^{1-\rho})} \]  

(B.5)

Using the labor supply (2.4) and risk-sharing condition (2.1), and taking expectation, we can get (3.14) of the paper:

\[ EL = \frac{n}{\hat{\lambda} \eta} E(C^{1-\rho}) + \frac{1 - n}{\hat{\lambda} \eta} E(C^{1-\rho}) \]

Analogously, we can get:

\[ EL^* = \Gamma^{-1} \frac{n}{\hat{\lambda} \eta} E(C^{1-\rho}) + \frac{1 - n}{\hat{\lambda} \eta} E(C^{1-\rho}) \]  

(B.6)

Then we can get the expected home country utility (3.15) and its foreign equivalent:

\[ EU^* = \frac{\lambda - (1-n)(\lambda - 1)(1-\rho)}{(1-\rho)\lambda} E(C^{1-\rho}) - \frac{n(\lambda - 1)}{\lambda} \Gamma^{-1} E(C^{1-\rho}) \]  

(B.7)
Calculating the variances and covariances  From the equations (3.4)-(3.6) and monetary policy rule (3.7) and (3.8), we can solve for the variances and covariances terms in Equation (3.11) and (3.12).

\[ \sigma^2_s = (a_1 - b_1)^2 \sigma_u^2 + (a_2 - b_2)^2 \sigma_u^* \]  \hspace{1cm} (B.8)

\[ \sigma^2_c = \frac{1}{\rho^2} [a_1^2 \sigma_u^2 + a_2^2 \sigma_u^*] \]  \hspace{1cm} (B.9)

\[ \sigma^2_{c^*} = \frac{1}{\rho^2} [(na_1 + (1 - n)b_1)^2 \sigma_u^2 + (na_2 + (1 - n)b_2)^2 \sigma_u^*] \]  \hspace{1cm} (B.10)

\[ \sigma^2_{cu} = \frac{1}{\rho} a_1 \sigma_u^2, \quad \sigma^2_{cu^*} = \frac{1}{\rho} a_2 \sigma_u^* \]  \hspace{1cm} (B.11)

\[ \sigma^2_{c^*u} = \frac{1}{\rho} [na_1 + (1 - n)b_1] \sigma_u^2, \quad \sigma^2_{c^*u^*} = \frac{1}{\rho} [na_2 + (1 - n)b_2] \sigma_u^* \]  \hspace{1cm} (B.12)

\[ \sigma_{su} = (a_1 - b_1) \sigma_u^2, \quad \sigma_{su^*} = (a_2 - b_2) \sigma_u^* \]  \hspace{1cm} (B.13)

Using the relationship

\[ EC^{1-\rho} = \exp \left\{ (1 - \rho) [E(c) + \frac{1 - \rho}{2} \sigma_c^2] \right\} \]  \hspace{1cm} (B.14)

we can express the expected home and foreign country utility as an function of monetary policy parameters \((a_1, a_2, b_1, b_2)\).

C  Proof of Proposition 4

When \(\rho = 1\), using equation (4.6) and (4.7), given the optimal monetary rules that \(a_1 = n, a_2 = 1 - n, b_1 = 0\) and \(b_2 = 1\), we can derive the expected utility for home country and foreign country.

\[ EU = -\frac{n(1 - n)}{2} [\sigma_u^2 + \sigma_u^*] \]  \hspace{1cm} (C.15)

\[ EU^* = -\frac{n(1 - n)^2}{2} [\sigma_u^2 + \sigma_u^*] \]  \hspace{1cm} (C.16)

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Thus, $EU < EU^*$.

When $\rho > 1$, using equation (4.2) and (4.3) and the fact that $\Gamma = (\frac{X}{X^*})^\rho$, we can simplify $EU$ and $EU^*$ as:

$$EU = \frac{\lambda - (\lambda - 1)(1 - \rho)}{(1 - \rho)\lambda} \Gamma X^*$$  \hspace{1cm} (C.17)

$$EU^* = \frac{\lambda - (\lambda - 1)(1 - \rho)}{(1 - \rho)\lambda} X^*$$  \hspace{1cm} (C.18)

Since $\frac{\lambda - (\lambda - 1)(1 - \rho)}{(1 - \rho)\lambda}$ is negative, to prove $EU < EU^*$ is equivalent to prove $\Gamma > 1$. We denote

$$\tilde{X} = -\frac{1}{2}\sigma^2_c - \frac{1}{2}\tilde{\sigma}_u + \tilde{\sigma}_{cu}$$  \hspace{1cm} (C.19)

$$\tilde{X}^* = -\frac{1}{2}\sigma^2_c^* - \frac{n(1 - n)}{2}\sigma^2_s - \frac{1}{2}\sigma^2_u + \tilde{\sigma}_{cu} + n(1 - n)(\sigma_{su} - \sigma_{su}^*)$$  \hspace{1cm} (C.20)

That is,

$$X = \Theta \exp[(1 - \rho)\tilde{X}]$$  \hspace{1cm} (C.21)

$$X^* = \Theta \exp[(1 - \rho)\tilde{X}^*],$$  \hspace{1cm} (C.22)

Since $\rho > 1$, to prove $\Gamma > 1$ is equivalent to prove $\tilde{X} < \tilde{X}^*$. Substituting the optimal monetary rules for the general case listed in table 1 into equation (C.19) and (C.20), we may have

$$\tilde{X}^* - \tilde{X} = A\sigma^2_u + A^*\sigma^2_u^*.$$  \hspace{1cm} (C.23)

Where

$$A = \frac{(1 - n)(a_1 - b_1)}{2\rho^2(n(\rho - 1) + 1)}[a_1 + n^2(\rho - 1)^3 + n(\rho - 1)(\rho + (\rho - 1)(1 - a_1))]$$  \hspace{1cm} (C.24)

$$A^* = \frac{(1 - n)(a_2 - b_2)}{2\rho^2(n(\rho - 1) + 1)}[a_2 - (1 - n)(\rho - 1)^2 + 2\rho - 1 - a_2n(\rho - 1)^2 - \rho n(n(\rho - 1)^2 + 2\rho - 1)]$$  \hspace{1cm} (C.25)
Given the properties of the optimal policy coefficients \(( n \leq a_1 < 1, b_1 < 0, a_1 - b_1 > 0, 0 < a_2 \leq 1 - n \) and \( a_2 - b_2 < 0)\), we can show

\[ A > 0, \quad A^* > 0 \quad \text{(C.26)} \]

That is, \( \tilde{X} < \tilde{X}^* \) and \( X > X^* \). Therefore,

\[ \Gamma = \left( \frac{X}{X^*} \right)^\rho > 1 \quad \text{(C.27)} \]

Thus, \( EU < EU^* \) when \( \rho > 1 \). Q.E.D.

## D Proof of Proposition 5

To prove Proposition 5, we need to show that there exists a positive menu cost such that the conditions under which the home firms follow PCP and the foreign firms follow LCP hold simultaneously, that is:

\[
\frac{1}{2} \sigma_s^2 - \text{Cov}(\ln \frac{W}{\theta}, s) > Z \quad \text{(D.28)}
\]

\[
\frac{1}{2} \sigma_s^2 + \text{Cov}(\ln \frac{W^*}{\theta^*}, s) < Z \quad \text{(D.29)}
\]

where \( Z = \frac{\bar{\delta}}{d\bar{\pi} \lambda (\lambda - 1)}, s = \ln S \).

**Step 1** To prove that both (D.28) and (D.29) hold is equivalent to prove the following inequality:

\[
\text{Cov}(\ln \frac{W}{\theta}, s) < -\text{Cov}(\ln \frac{W^*}{\theta^*}, s) \quad \text{(D.30)}
\]

Using the labor supply function \( W = \eta PC^\rho \) and money demand function \( M = \chi PC^\rho \), we can write inequality (D.30) as

\[
\text{Cov}(s, m - u) < -\text{Cov}(s, m^* - u^*) \quad \text{(D.31)}
\]
Given the monetary policy rules (3.7) and (3.8), (D.31) becomes:

\[ \text{Cov}[(a_1-b_1)u+(a_2-b_2)u^*, (a_1-1)u+a_2u^*] < -\text{Cov}[(a_1-b_1)u+(a_2-b_2)u^*, b_1u+(b_2-1)u^*] \]  
\[ \text{(D.32)} \]

Using the property that \( u \) and \( u^* \) are i.i.d, (D.32) could be rewritten as:

\[ (a_1-b_1)(a_1+b_1-1)\sigma_u^2 + (a_2-b_2)(a_2+b_2-1)\sigma_{u^*}^2 < 0 \]  
\[ \text{(D.33)} \]

From the optimal monetary rules listed in Table 1, we have \( a_1 + a_2 = 1, b_1 + b_2 = 1, \) \( n \leq a_1 < 1, b_1 \leq 0, 0 < a_2 \leq (1-n) \) and \( b_2 \geq 1, \) this implies

\[ (a_1-b_1)(a_1+b_1-1) = (a_2-b_2)(a_2+b_2-1) < 0 \]  
\[ \text{(D.34)} \]

Thus, we show that the two conditions (D.28) and (D.29) hold.

**Step 2** We need to show there exists a positive \( \delta \) (or \( Z \)). Defining the left side term in equation (D.28) and (D.29) as \( Z_1 \) and \( Z_2 \), respectively, and using equation (D.28) and the properties of optimal policy parameters (\( a \)'s and \( b \)'s), we have

\[
Z_1 = \frac{1}{2}[(a_1-b_1)^2\sigma_u^2 + (a_2-b_2)^2\sigma_{u^*}^2] - [(a_1-b_1)(a_1-1)\sigma_u^2 + (a_2-b_2)a_2\sigma_{u^*}^2]
\]

\[
= (a_1-b_1)\left(\frac{a_1-b_1}{2} + 1 - a_1\right)\sigma_u^2 + (a_2-b_2)\left(\frac{a_2-b_2}{2} - a_2\right)\sigma_{u^*}^2 > 0
\]  
\[ \text{(D.35)} \]

From equation (D.30), we have \( Z_2 < Z_1 \). Therefore, there must exist a positive \( Z \in (Z_2, Z_1) \) such that (D.28) and (D.29). Q.E.D.
Table 1
The optimal monetary rule in Nash game

<table>
<thead>
<tr>
<th>Parameters</th>
<th>( \rho &gt; 1 )</th>
<th>( \rho = 1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a_1 )</td>
<td>( \frac{\rho n + (1-n) \delta_1 - n(\rho-1) \delta_2}{\rho n + (1-n) \delta - n(\rho-1) \delta_2} )</td>
<td>( n )</td>
</tr>
<tr>
<td>( a_2 )</td>
<td>( \frac{\rho n + (1-n) \delta_3}{\rho n + (1-n) \delta - n(\rho-1) \delta_2} )</td>
<td>( 1 - n )</td>
</tr>
<tr>
<td>( b_1 )</td>
<td>( \frac{-n(\rho-1) \delta_3}{\rho n + (1-n) \delta - n(\rho-1) \delta_2} )</td>
<td>( 0 )</td>
</tr>
<tr>
<td>( b_2 )</td>
<td>( \frac{\rho n + (1-n) \delta - n(\rho-1) \delta_2 + n(\rho-1) \delta_3}{\rho n + (1-n) \delta - n(\rho-1) \delta_2} )</td>
<td>( 1 )</td>
</tr>
</tbody>
</table>

Where \( \delta = \hat{\lambda} - n(1 - \rho) \{ 1 + (1 - n)[\rho(1 - n) + n] \} \)

\( \delta_1 = n \left\{ \hat{\lambda} - (1 - \rho) [n + (1 - n)[\rho(1 - n) + n]] \right\} \)

\( \delta_2 = n [(1 - n)(1 - \rho)]^2 \)

\( \delta_3 = (1 - n) \hat{\lambda} - n(1 - \rho) \)

and \( \delta_1 + \delta_3 = \delta \)
Table 2
The weight on exchange rate volatility in monetary policy decision

\[(\rho > 1, n = 0.5, \sigma_u^2 = \sigma_u^2* = 0.0004, \hat{\lambda} = 1.1 )\]

<table>
<thead>
<tr>
<th>Weight</th>
<th>(\rho = 1.5)</th>
<th>(\rho = 2)</th>
<th>(\rho = 3)</th>
<th>(\rho = 4)</th>
<th>(\rho = 6)</th>
<th>(\rho = 8)</th>
<th>(\rho = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>-0.04</td>
<td>-0.114</td>
<td>-0.341</td>
<td>-0.683</td>
<td>-1.710</td>
<td>-3.2</td>
<td>-12.190</td>
</tr>
<tr>
<td>Foreign</td>
<td>-0.23</td>
<td>-0.364</td>
<td>-0.716</td>
<td>-1.182</td>
<td>-2.456</td>
<td>-4.184</td>
<td>-13.825</td>
</tr>
<tr>
<td>Ratio</td>
<td>0.185</td>
<td>0.317</td>
<td>0.476</td>
<td>0.579</td>
<td>0.696</td>
<td>0.765</td>
<td>0.882</td>
</tr>
</tbody>
</table>

a. The weight on exchange rate volatility in monetary policy decision for home and foreign monetary authorities are measured by

\[
\frac{\partial EU}{\partial \sigma_s^2} = -\frac{(1-n)}{\lambda} \Gamma \frac{\partial X^*}{\partial \sigma_s^2} < 0, \quad \frac{\partial EU^*}{\partial \sigma_s^2} = \left[ \frac{1}{1-\rho} - \frac{(1-n)}{\lambda} \right] \frac{\partial X^*}{\partial \sigma_s^2} < 0
\]

where \(\frac{\partial X^*}{\partial \sigma_s} > 0\), and \(\Gamma\) is endogenously determined by equation 2.2.
Figure 1: The reaction curves for $a_1, b_1$ ($\rho = 4$, $n = 0.5$ and $\lambda = 6$)

Figure 2: The reaction curves for $a_2, b_2$ ($\rho = 4$, $n = 0.5$ and $\lambda = 6$)