What Drives Volatility in Real Exchange Rates? Evidence for Industrial Countries

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First Version: January 2003
This Version: November 2003

(Very Preliminary Version and Incomplete. Please Do Not Quote)

Abstract
A recent strand of the literature, the so-called "New Open Economy Macroeconomics", argues that non-monetary factors have gained importance in explaining exchange rate volatility. That is, in addition to money, we should include productivity shocks, terms of trade shocks, and government spending, among others. The goal of the present paper is to explain the real exchange rate volatility by positing a structural relationship between volatility and its determinants. The set of forcing variables will be determined by a dynamic general equilibrium model in the spirit of Obstfeld and Rogoff (2000) that includes government.

In order to perform our task we will gather information on exchange rates, productivity of the traded and non-traded sector, terms of trade, government spending, monetary aggregates, interest rates, exchange rate regimes, and capital controls for a sample of industrial and emerging-market countries for the 1973-2001 period. We will use the recent technique developed by Bekaert, Harvey and Lunnblad (2001, 2002) that allows us to use overlapping data (specially suitable for variables in standard deviation) and exploit both the time dimension and cross-sectional dimension of our data base.

JEL Classification: F31, F41, C23

Key Words: Real Exchange Rate Volatility, Openness, Panel Data
1. Introduction

The collapse of Bretton Woods in 1971 forced industrial economies to switch from a fixed exchange rate to a floating system. This switch brought a larger volatility for both the nominal and the real exchange rate (Stockman, 1983; Mussa, 1986). During the 1970s, the great volatility of the exchange rate was blamed to the monetary authorities. Theoretically, Dornbusch (1976) showed that unanticipated monetary policy shocks might generate disproportionately large fluctuations in the exchange rates. In Dornbusch’s model, the lower speed of adjustment of goods markets implies that the exchange rate disproportionately absorbs the unanticipated monetary shock in the short run.

However, the hypothesis that monetary stability is the sole culprit of exchange rate instability has lost ground as most industrial economies have stabilized inflation at annual rates below 3 percent. For example, inflation rates have converge to the 1 to 2 percent rage in the U.S., Japan, and Europe; whereas the exchange rates across the US dollar, the euro, and the yen are still significantly volatile (Rogoff, 1999). The fact that exchange rate volatility among the major currencies has not declined even though the serious and successful efforts to bring inflation down, allows us to think that the role of monetary factors implied by Dornbusch (1976) was overstated. In addition, the inability of monetary models to replicate and forecast exchange rate fluctuations (Meese and Rogoff, 1983) implies that monetary instability is only one of the several factors driving exchange rate volatility.

A recent strand of the literature, the so-called "New Open Economy Macroeconomics", argues that non-monetary factors have gained importance in explaining exchange rate volatility. That is, in addition to money, we should include productivity shocks, terms of trade shocks, and government spending, among others. The goal of the present paper is to explain the real exchange rate volatility by positing a structural relationship between volatility and its determinants. The set of forcing variables will be determined by a dynamic general equilibrium model in the spirit of Obstfeld and Rogoff (2000) that includes government.

In order to perform our task we will gather information on exchange rates, productivity of the traded and non-traded sector, terms of trade, government spending, monetary aggregates, interest rates, exchange rate regimes, and capital controls for a sample of industrial and emerging-market countries for the 1973-2001 period. We will use the recent technique developed by Bekaert, Harvey and Lunnblad (2001, 2002) that allows us to use overlapping data (specially suitable for variables in standard deviation) and exploit both the time dimension and cross-sectional dimension of our data base.

The paper will consist of the following sections: Section 2 presents the model with nominal rigidities and imperfect competition a la Obstfeld-Rogoff (2000). From this model, we obtain the main determinants of real exchange rate volatility. Section 3 discusses the method of estimation. We use the technique proposed by Bekaert et al. (2001, 2002) that we summarize above. Section 4 discusses the data used and presents some stylized facts on exchange rate volatility. Section 5 presents the estimation results. Section 6 concludes.

2. The Model

We use the textbook model of Obstfeld and Rogoff (1996) as a general framework to extract inferences on the volatility of real exchange rate fluctuations. We consider a small country model with the non-traded sector being the locus of the monopoly and sticky price problems, and where the traded sector has a single homogeneous output that is priced in competitive world markets. Each representative agent of the Home country is endowed with a constant quantity of
the traded good each period, $\bar{y}_T$, and has a monopoly power over one of the non-tradables goods $z \in [0,1]$. We assume that all agents have similar preferences throughout the world over a real consumption index and work effort. Given the symmetry in preferences and budget constraints across agents, we solve the optimization problem for the representative national consumer-producer.

2.1 Set up

The intertemporal utility function of the typical Home agent $j$ is given by:

$$U_j^t = \sum_{s=t}^{\infty} \beta^{s-t} \left[ \phi \ln C_{j,s}^t + (1 - \phi) \ln C_{N,s}^j + \frac{\chi}{1 - \epsilon} \left( \frac{M_j^t}{P_s} \right)^{1 - \epsilon} - \frac{\kappa}{2} y_{N,s}^2 \right]$$

(1)

where $\beta \in (0,1)$, and $\sigma, \kappa > 0$. On the other hand, $C_T$ represents the consumption of traded goods, and $C_N$ is the composite consumption of non-traded goods:

$$C_N = \left[ \int_0^1 c_N(z)^{\theta-1} dz \right]^{\theta-1}$$

(2)

In addition, $P$ is the consumption-based price index (defined as the minimum cost of purchasing an additional unit of real consumption $C_T^\gamma C_N^{1-\gamma}$),

$$p_N = \left[ \int_0^1 p_N(z)^{1-\theta} dz \right]^{1-\theta}$$

(3)

where $p_N(z)$ is the price of non-traded good $z$. Bonds are denominated in tradables, with $r$ denoting the constant world net interest rate in tradables and $\beta(1+r) = 1$. The typical household $j$’s period nominal budget constraint is:

$$P_{T,j} F_t^j + M_t^j = P_{T,j} (1 + r) F_t^j + M_{t-1}^j + p_N(j) y_{N,t}(j) + p_{T,j} \bar{y}_{T,t} - P_{N,j} C_{N,t}^j - P_{T,j} C_{T,t}^j - P_{T,t} \tau_t$$

(4)

where $F_t$ denotes real bonds (in units of the tradable good) that pay off a real return $r$, and $\tau_t$ represents taxes per capita in terms of the tradable goods. Abstracting from government spending, we assume that the government balances its budget each period (in units of tradables),

$$\frac{M_t - M_{t-1}}{P_t} + \tau_t = 0$$

(5)

Finally, the producer of non-traded goods face the following demand curve:

$$y_{N,t}^\sigma = \left[ \frac{p_{N,t}(j)}{p_{N,t}} \right]^{-\theta} C_N^A$$

(6)

where $C_N^A$ represents Home's aggregate consumption of non-traded goods.

\(^1\)Disutility in producing more output is captured by the term $-(\kappa/2)y_{N,s}^2$. Assuming that disutility from effort $l_N$ is given by $-\psi^l_N$ and that $y_{N}\equiv A^l N^\alpha$ ($\alpha<1$), then $\kappa = 2 \psi / A^{1+\alpha}$. The output term in equation (1) is obtained when $\alpha = 0.5$. A rise in productivity $A$ is here captured by a fall in $\kappa$ (Obstfeld and Rogoff, 1996).
To solve the agent's optimization problem, we maximize equation (1) subject to equations (4) and (6). The solution for the paths of consumption (tradable and non-tradable), money and work effort might meet the following first-order conditions:

\[
C_{T,t+1} = C_{T,t} \tag{7}
\]

\[
\frac{\phi}{P_{T,t} C_{T,t}} = \chi \left( \frac{M_t}{P_t} \right) ^{-\varepsilon} + \beta \left( \frac{P_{T,t}}{P_{T,t+1}} \right) \left( \frac{\phi}{C_{T,t+1}} \right) \tag{8}
\]

\[
\frac{C_{N,t}}{C_{T,t}} = \frac{1 - \phi}{\phi} \left( \frac{P_{N,t}}{P_{T,t}} \right) ^{-1} \tag{9}
\]

\[
y_{N,t} = \frac{(\theta - 1)(1 - \phi)}{\theta \kappa} C_{N,t}^{-1 / \theta} \left( C_{N,t}^A \right) ^{1 / \theta} \tag{10}
\]

Equation (7) reflects the Euler equation for optimal intertemporal consumption smoothing for traded goods. Note that our assumption $\beta (1 + r) = 1$ was instrumental in obtaining a traded version of Hall’s result. Equation (8) depicts the utility maximizing trade-off between spending on tradables in period $t$ and a combination of one-period money holding and consumption spending in period $t+1$. Equation (9) states the marginal rate of substitution between traded and non-traded goods must be constant over time. Note that according to this condition, we can define the degree of openness as $\frac{P_t C_T}{P_t C_T + P_t C_N} = \phi$. Finally, the equilibrium supply of non-tradables is presented in equation (10). This relationship establishes the condition for price-setting strategy for monopolistically competitive firms in the optimum.2

We obtain the demand for real balances by replacing (7) into (8),

\[
M_L = \chi \frac{C_{T,t}}{P_t} \left( 1 - \beta \frac{P_{T,t}}{P_{T,t+1}} \right) \tag{11}
\]

with the demand depending upon the consumption of tradables, changes in the price of tradables and changes in the real price of tradables.

### 2.2. Approximate Solution

Here we describe the steady state solution of this economy under the assumption that all prices are fully flexible and all our exogenous variables are constant. We first assume that the economy has zero initial net foreign assets. Given that the production of tradables is constant in this model at $y_T$, and the first-order condition of consumption smoothing in tradables, equation (7), we find that $C_{T,t} = y_T$, for all $t$. Analogously, a symmetric equilibrium for the market of non-tradables implies that $C_{N,t} = y_{N,t}(z) = C_{N,t}^A$, for all $z$ non-traded goods.

Combining equations (9) and (10), we obtain the steady state level for the consumption and production of non-traded goods:

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2 Hau (2002) interprets this condition as the marginal utility of an additional unit of non-traded consumption being equal to the marginal disutility of the production of an extra unit. According to this strategy, a mark-up of $\theta/(\theta-1)$ is added by monopolistically competitive firms.
\[ Y_N = C_N = \left( \frac{(\theta - 1)(1 - \phi)}{\theta \kappa} \right)^{\frac{1}{2}} \]  

(12)

In this model, steady state prices for traded goods determine the aggregate price level:

\[ P = \frac{\phi}{\chi} (1 - \beta) \left( \frac{M}{C_T} \right) \]  

(13)

whereas the steady state nominal exchange rate is:

\[ E = \frac{\phi}{\chi} (1 - \beta) \left( \frac{M}{C_T} \right) \frac{1}{P^*} \]  

(14)

**Impact of Unanticipated Permanent Monetary and Productivity Shocks**

According to the model, prices in the competitive tradable sector are fully flexible, whereas prices in the monopolistic non-traded goods sector are set a period in advance (and they adjust only in period 2). Since there are no current account effects, money is neutral in the long run, and only nominal variables change across the steady state.

In the short run, prices on non-traded goods are fixed at \( p_{N,0} \), and the output of non-traded goods is determined by demand. By symmetry across several domestic producers, we have that \( p_{N,0} = P_{N,0} \). The short run demand is given by \( y_N' = C_N \).

If we combine equation (9), with the equilibrium in tradables, and the short-run demand for non-tradables, we find that the output and consumption of non-tradables can be expressed as a function of the tradable prices,

\[ y_N = C_N = \left( \frac{1 - \phi}{\phi} \right) \left( \frac{P_T}{P_N} \right) [N_T] \]  

(15)

Next, we take a log-linear approximation around the benchmark steady state. We denote \( X = \left( \frac{X - X_0}{X_0} \right) \) as the short-run percentage deviation from the benchmark steady-state, and \( \hat{X} = \left( \frac{X - X_0}{X_0} \right) \) as the long-run deviations from the same steady state.

**Monetary Shocks.** Assume that (ceteris paribus) the economy faces only unanticipated permanent monetary shocks, i.e. \( \hat{M} = \tilde{M} \). Solving for the relative variables: First, we log-linearize the money demand, equation (11) around the steady state:

\[ \varepsilon(\tilde{m} - \tilde{p}) = (\tilde{p}_T - \tilde{p}) + \frac{\beta}{1 - \beta} (\tilde{p}_T - \tilde{p}_T) \]  

(16)

Given that prices of nontradables are fixed in the short-run, \( \tilde{P}_N = 0 \), we can express the short-run deviations of the aggregate prices around the steady state as \( \tilde{P} = \phi \tilde{P}_T \). Also, given the non-neutrality of money, \( \tilde{P}_T = \tilde{M} = \tilde{M} \). Substituting these results in (16), we have:

\[ \tilde{P}_T = \frac{\beta + (1 - \beta)\varepsilon}{\beta + (1 - \beta)(1 - \phi + \phi\varepsilon)} \tilde{M} \]  

(17)

\(^3\) Note that if \( \phi = 1 \), \( \tilde{P}_T = \tilde{M} \).
According to our model, the law of one price holds for traded goods. Hence, prices of traded goods change in proportion to exchange rate fluctuations, i.e. \( \tilde{P}_T = \tilde{E} \). In addition, changes in the real exchange rate are defined as,

\[
\tilde{q} = \tilde{E} - \tilde{P} = \tilde{E} - \phi \tilde{P}_T = (1 - \phi) \tilde{P}_T = h(\phi)\tilde{P}_T
\] (18)

where \( h(\phi) \) is a function that depends inversely upon the degree of openness \( \phi \). Using (18), the volatility of real exchange rate changes is:

\[
\sigma(\tilde{q}) = \overline{h}(\phi)\sigma(\tilde{M})
\] (19)

where \( \sigma(\cdot) \) represents the standard deviation of certain variable and \( \overline{h}(\phi) \) is the function that relates the volatility of real exchange rate fluctuations and the degree of openness. We can show that this relationship is negative.

**Productivity Shocks.** Assume that (ceteris paribus) the economy faces only unanticipated permanent technology shocks in the non-traded sector, i.e. \( \hat{A}_N = \hat{A}_N^* \). If we log-linearize equation (10), we have:

\[
-\tilde{P}_T - \tilde{C}_T = -\hat{A}_N + \tilde{y}_N
\] (20)

Given the assumption of constant endowments of traded goods, \( \tilde{y}_T \), a constant net foreign asset position, and the consumption-smoothing motive, we have \( \tilde{C}_T = 0 \). If we log-linearize (9), \( \tilde{C}_N = \tilde{P}_T \), given that \( \tilde{P}_N = 0 \). Market-clearing conditions for non-tradables, \( \tilde{C}_N = \tilde{y}_N \), then determines the fluctuations in the prices of traded goods, \( \tilde{P}_T = -\frac{1}{2} \hat{A}_N \). Again, since the law of one price for tradables holds, we find that real exchange rate fluctuations are

\[
\tilde{q} = \tilde{E} - \tilde{P} = \tilde{E} - \phi \tilde{P}_T = (1 - \phi) \tilde{P}_T = -\left(1 - \frac{\phi}{2}\right)\hat{A}_N
\] (21)

Hence, from (21), we find that the volatility of real exchange rate changes is:

\[
\sigma(\tilde{q}) = \frac{(1 - \phi)^2}{4} \sigma(\hat{A}_N)
\] (19)

where the greater the degree of openness, the smaller the link between the volatility of productivity shocks and the volatility of real exchange rate fluctuations.

### 3. Methodology

Denote the first differences of the log of the exchange rate for country \( i \) between year \( t \) and \( t+1 \) as \( dq_{i,t+1} \). Our main interest is to study the determinants of the volatility of exchange rate changes. Following Bekaert et al. (2002), we construct two time series measures of growth rate variability:

\[
\text{Range}_{i,t+k} = \max_{j=1,...,k} dq_{i,j+t} - \min_{j=1,...,k} dq_{i,j+t} ; \quad i = 1,...,N
\]

\[
\text{Stdev}_{i,t+k} = \sigma_{j=1,...,k} (dq_{i,j+t}) ; \quad i = 1,...,N
\]

\( \text{Range}_{i,t+k} \) is the high-low range of exchange rate changes observed over \( k \) years. This indicator allows us to avoid the implicit estimation of the mean inherent in standard deviation
calculations. In addition, we also compute the variability of exchange rate changes, $Stdev_{l,t+k,k}$, over $k$ years.

Using a set of determinants implied in our model, our primary regressions can be specified as follows:

$$Range_{l,t+k,k} = X_i \beta + \epsilon_{l,t+k,k}$$

(2)

$$Stdev_{l,t+k,k} = X_i \beta + \epsilon_{l,t+k,k}$$

The matrix $X_i$ controls for forcing variables that may explain the exchange rate volatility: openness, output per capita, terms of trade volatility, exchange rate regime, capital controls, and monetary divergence. The framework proposed by Bekaert et al. (2001, 2002) maximizes the time-series content in the regressions by using overlapping data. This method deals with the resulting moving average component in the residuals by adjusting the standard errors as a cross-sectional extension to Hansen and Hodrick (2001).

If our regressors are pre-determined, we identify the parameters by assuming:

$$E \begin{bmatrix} \epsilon_{l,t+k,k} \otimes X_{1,t} \\ \vdots \\ \epsilon_{N,t+k,k} \otimes X_{N,t} \end{bmatrix} = 0$$

(3)

The estimator of $\beta$ can be written as:

$$\hat{\beta} = \left[(X'Z)S_T^{-1}(Z'X)\right]^{-1}\left[(X'Z)S_T^{-1}(Z'Y)\right]$$

(4)

where $Y_i$ is equal to $\{Range_{l,t+k,k}\}$ or $\{Stdev_{l,t+k,k}\}$, and given $X_i = [X_{i,t'}]$.

$$X = \begin{bmatrix} X_1 \\ \vdots \\ X_N \end{bmatrix} ; \quad Z = \begin{bmatrix} X_1 & 0 & \cdots & 0 \\ 0 & X_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & X_N \end{bmatrix}$$

In addition, $S_T$ is the estimated covariance matrix of the sample orthogonal conditions specified in equation (3), taking into account for the autocovariances induced by the overlap.

Bekaert et al. (2002) points out that an specification such as the one presented in equation (2), facilitates cross-sectional heteroskedasticity and SUR effects, but not temporal heteroskedasticity. Then, they define the NxN matrix $\hat{\Omega}_j$ as follows:

$$\hat{\Omega}_j = \frac{1}{T} \sum_{l=j+1}^T (e_{l+k}^T e_{l-k-j}^T)$$

The restricted covariance matrix can then be written as follows:

$$\hat{\Omega}_j = \frac{1}{T} \sum_{l} Z_l^T \hat{\Omega}_0 Z_l + \sum_{j=1}^K \left( \sum_{l=j+1}^T (Z_l^T \hat{\Omega}_j Z_{l-j} + Z_l^T \hat{\Omega}_j Z_l) \right)$$

where $K$ represents the number of lags. Given the small time dimension in the sample, the small sample properties of the estimator in this framework are questionable (Bekaert et al., 2001, 2002). As a result, it is recommended to restrict the non-diagonal terms of $\hat{\Omega}_j$ to be identical:
The number of parameters in the weighting matrix structure declines significantly with this restriction, and it still retains some of the SUR flavor.

4. Data and Facts

4.1 The Data

We collect quarterly data on real exchange rates, output, and money as well as annual data on some structural macroeconomic variables for a sample of 21 industrial countries over the 1960-2002 period.

Regarding our dependent variable, we construct the real effective exchange rate as the nominal exchange rate multiplied by the relative price of the rest of the world (expressed in US dollars) to the domestic price index,

$\text{REER}_{kt} = \frac{\epsilon_t^{e} \left( \prod_{i=1}^{n} \left( \frac{p_{ij}^{e}}{p_{ij}^{d}} \right) \right)^{\omega}}{\text{IPC}_{kt}}$

where $\epsilon_t^{e}$ is the nominal exchange rate for country k observed in period t, IPC is the consumer price index of country k in period t, $e_i^{i}$ is the nominal exchange rate of the i-th trading partner in period t in units of local currency vis-a-vis the US dollar, and $p_i^{i}$ is the wholesale price index of country k’s ith trading partners in period t.4 Our dependent variable (i.e. real exchange rate volatility) is the standard deviation of the (quarterly) real exchange rate changes, computed for periods of 3, 4, and 5 years.

Among our explanatory variables, we have:

**Output and Monetary Volatility.** The first one is measured by the standard deviation of (quarterly) changes in the industrial production index, whereas the second one is captured by the standard deviation of (quarterly) changes in the monetary base. Note that both (a) and (b) are standard deviation of quarterly changes for 3 through 5 year periods.

**Openness and Exchange Rate Regime.** Using data from the World Bank’s World Development Indicators, we construct the degree of openness as the ratio of exports and imports to GDP. On the other hand, data on the nominal exchange rate regime taken from Reinhart and Rogoff (2002).

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4 Data on exchange rates are drawn from the line $\text{rf}$ of the IMF’s International Financial Statistics, which represents the average nominal exchange rate for the period. To approximate domestic prices, we use the consumer price index (CPI) because of the timeliness of publication and the availability of the data on a monthly and quarterly basis. Finally, there is a consensus among economists that the index of foreign prices should include mainly prices of tradable goods, whereas the domestic price level should comprise prices of both tradable and non-tradable goods. For this reason, economists have increasingly used foreign wholesale price indices in the construction of $p^*$. The weights are computed using bilateral trade flows between the countries involved in our analysis.
Capital Controls. We use two proxies for capital controls. First, we consider four forms of BoP restrictions recorded by the IMF’s Exchange Arrangements and Exchange Restrictions: (i) restrictions on payments for capital transactions; (ii) multiple exchange rate practices; (iii) restrictions on current account transactions, and (iv) surrender of export proceeds. For each of these categories, the IMF records a score of 1 when restrictions apply, and 0 otherwise. Our proxy is the first principal component of these indicators as shown in Chinn and Ito (2002). Finally, we also use the black market premium on foreign exchange as an alternative measure of capital and current account controls (Dooley and Isard, 1980). Data on black market premium is obtained from Wood (1988) and International Currency Analysis Global Currency Report (various issues).

4.2 Stylized Facts

Before we carry out our regression analysis, we present certain regularities observed in the real exchange rate volatility for industrial economies.

- There is a negative and significant association between real exchange rate volatility and the degree of openness in the economy (see Figure 1).

Real exchange rate volatility and openness exhibit a negative and significant correlation for industrial economies (-0.13), with the correlation being significantly smaller for G7 countries. If the degree of openness increases by one standard deviation (approximately 0.26), volatility of real exchange rate changes from an average of 0.0236 (for 5-year period observations) to 0.022. This result is consistent with Hau (2002), where both monetary and supply shocks are shown to produce smaller exchange rate movements if the country is more open to foreign trade.

- The more flexible the nominal exchange rate regime is, the higher the volatility exhibited by the real exchange rate (see Figure 2).

There is ample evidence that the real exchange rate has become more volatile after the collapse of Bretton Woods (Stockman, 1983; Mussa, 1986), when most industrial countries adopted more flexible monetary arrangements. The correlation between real exchange rate and nominal exchange rate regime is positive and significant (recall that higher values represent more flexible arrangements), with the correlation for G7 countries being only slightly larger (0.52 vs. 0.49). Economically speaking, moving from a more flexible arrangement (say, from a moving crawling peg to managed floating) will increase the volatility of real exchange rate changes from an average of 0.0236 (for 5-year period observations) to 0.0295.

- There is not robust evidence on the link between real exchange rate volatility and capital controls (see Figures 3 and 4).

The correlation between real exchange rate volatility is positive not significant for the sample of industrial countries (0.0204), whereas as it is negative and still not significant for G7 countries (-0.0426). Note that the failure of this correlation to be significant might be attributed to the fact that this proxy captures the presence of controls and not their intensity. Economically speaking, the impact is small. If there is one more control present in the economy, the volatility of exchange rate changes will decrease from an average of 0.0236 to 0.0225.

5. The Evidence

In the present section, we present evidence on the determinants of real exchange rate volatility for a sample of 21 industrial countries over the 1960-2002 period. As we stated in the previous sections, our dependent variable is the volatility of exchange rate fluctuations measured by the
standard deviation of quarterly changes in the exchange rate. Note that for robustness, we perform our regression analysis for standard deviations computed over 3 through 5-year periods.

We first characterize our dependent variable by regressing it on several structural indicators of the economy. Those results are presented in Table 1. There, we find that the real exchange rate volatility has a positive and significant relationship regardless of the time horizon over which the volatility measure is constructed. Note that the higher the time horizon of the volatility calculated \((k = 3, 4\text{ and } 5)\), the lower is the coefficient.

We can not find a robust relationship between real exchange rate volatility and capital controls, whether we measure them with the first principal components of the capital control dummies or the black market premium. We find a positive although not significant relationship if we use the dummy variables, and we find a negative relationship and significant only in 4- and 5-year horizons.

Finally, we find a robust negative association between real exchange rate volatility and the degree of openness. Note that the coefficient becomes more negative as the time horizon increases. Hence, if the degree of openness increases by one standard deviation, the volatility of the real exchange rate fluctuations decreases from 0.0227 to 0.0197 in the 3-year horizon sample and from 0.0236 to 0.0196 in the 5-year horizon sample.

In Table 2, we present the relationship between real exchange rate volatility, output volatility and openness. As shown in the theoretical model, the impact of productivity shocks on real exchange rate fluctuations is smaller if the economy is more outward-oriented. Therefore, in our regression analysis we include output volatility and the interaction term between output volatility and openness. We expect these variables to have a positive and negative coefficient, respectively.

We find that higher output volatility is associated with higher real exchange rate volatility, with the coefficient being significant at the 10 percent level regardless of the specification and the horizon. We also find that there is a turning point for the degree of openness in which the impact of output volatility turns negative. As the number of years used for volatility calculations increases, the degree of openness needed to have a zero impact is smaller. For 3-year period volatility, this threshold level for the degree of openness (trade as a ratio to GDP) is approximately 0.47, whereas for the 5-year period volatility it is 0.40 (Note that the average degree of openness for the sample of industrial countries is 0.47, and for G-7 countries is 0.32).

In Table 3, we perform a similar exercise but for monetary volatility. We also find that the higher the volatility of changes in monetary variables, the higher the volatility of exchange rates. We also find that the impact of monetary shocks on real exchange rate fluctuations decreases if the economy has a higher degree of openness to international trade.

Specifically, we find that the coefficient of monetary volatility is positive and significant at the 5 percent level for all the specifications and time horizons presented in Table 3. On the other hand, the interaction term between monetary volatility and openness is negative and significant in all the specifications. We find that this interaction term is negative and significant at the 5 percent level for all horizons (see Table 3).

Given the pattern of signs showed by the monetary volatility and its interaction term with openness, we can also find the level of openness that yields a zero impact of monetary volatility on real exchange rate volatility. We find that this trade to GDP ratio is approximately equal to 0.49 for all specifications in Table 3.

In Table 4, we present our complete specification, with the real exchange rate volatility depending on output and monetary volatility (including their interaction terms with the degree
of openness), and other variables such as output per capita, exchange rate regime, and capital controls. We confirm our results that the exchange rate regime has a positive and significant coefficient, and that there is no robust relationship between real exchange rate volatility and capital controls.

We find that the coefficient of output volatility is positive and significant at the 10 percent level only in the 3-year horizon sample. Note that the interaction term between output volatility and the degree of openness is negative and significant at the 5 percent level in all the specifications presented in Table 4. In this case, the threshold level of openness that yields zero impact decreases as the horizon to compute the real exchange rate volatility increases.

Regarding monetary volatility, its coefficient is positive and significant at the 5 percent level for all the specifications and time horizons presented in Table 4. On the other hand, the interaction term between monetary volatility and openness is negative although not significant in all the specifications. We find that this interaction term is negative and significant at the 10 percent level in shorter horizons (e.g. 3-year period volatility measures). We find that the level of openness that yields a zero impact of monetary volatility on real exchange rate volatility increases as the horizon of the volatility measures raises. For example, this threshold level is equal to 0.59 for the 3-year horizon sample and 0.70 for the 5-year horizon sample.

6. Conclusions

Using a model in the spirit of the “New Open Economy Macroeconomics”, we find that the explanation power of output and monetary volatility increases if we include the degree of openness of the economy. Specifically, we find that the impact of output and monetary shocks generates smaller real exchange rate fluctuations if the economy is more open to international trade.

To perform our task we gathered information on exchange rates, output, and money indicators, as well as some structural macroeconomic variables (e.g. exchange rate regimes, capital controls, output per capita) for a sample of 21 industrial countries for the 1960-2002 period. We used the recent technique developed by Bekaert, Harvey and Lunblad (2001, 2002) that allows us to use overlapping data (specially suitable for variables in standard deviation) and exploit both the time dimension and cross-sectional dimension of our data base.

In general, we find that:

- Real exchange rate volatility is higher if the monetary arrangement is more flexible. For example if the exchange rate regimes goes from a pre-announced crawling band (narrower than or equal to +/-2%) to a wider band (narrower than or equal to +/-5%) or a managed floating, the real exchange rate volatility would increase from an average of 0.0227 to 0.0277 for the 3-year horizon sample, and from an average of 0.0236 to 0.0278 for the 5-year horizon sample.

- The impact of capital controls approximated by black market premium negligible. An increase in the black market premium of one standard deviation (2.5 percent over the official rate) will decrease the 3-year volatility from 0.0227 to 0.0224, and the 5-year volatility from 0.0236 to 0.0228.

- We find a robust negative relationship between the volatility of real exchange rate fluctuations and the degree of openness. This result is consistent with Hau (2002). Specifically, we find that if the degree of openness increases by one standard deviation, the
3-year period volatility decreases from 0.0227 to 0.0197, whereas the 5-year period volatility declines from 0.0236 to 0.0196.

- We also find that monetary and productivity shocks generate smaller real exchange rate fluctuations if the economy has a higher degree of openness.

Finally, this first draft is still preliminary. There are some avenues that we are currently working on:

(a) Expand the sample to include some emerging market economies.
(b) Incorporate government sector in our model.
(c) Include government shocks and terms of trade fluctuations in our empirical analysis.

References


International Currency Analysis (various years), Global Currency Report.


Table 1
Characterizing the Real Exchange Rate Volatility
Sample of Industrial Countries, 1960-2002
Dependent Variable: Standard Deviation of (quarterly) Real Effective Exchange Rate Changes
\(k = \text{number of years}\)

<table>
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<tbody>
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<td>GDP per capita (logs)</td>
<td>0.01041 ** (0.0021)</td>
<td>0.01108 ** (0.0021)</td>
<td>0.01130 ** (0.0020)</td>
<td>0.01179 ** (0.0020)</td>
<td>0.01129 ** (0.0019)</td>
<td>0.01169 ** (0.0019)</td>
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<td>Exchange Rate Regime</td>
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<td>0.00521 ** (0.0005)</td>
<td>0.00496 ** (0.0005)</td>
<td>0.00488 ** (0.0005)</td>
<td>0.00468 ** (0.0005)</td>
<td>0.00458 ** (0.0005)</td>
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<td>-.-</td>
<td>-0.02697 * (0.0164)</td>
<td>-.-</td>
<td>-0.03527 ** (0.0154)</td>
<td>-.-</td>
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<tr>
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<td>0.00050 (0.0004)</td>
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<td>0.00048 (0.0004)</td>
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<td>Degree of Openness</td>
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<td>777</td>
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<td>(R^2)</td>
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Table 2
Real Exchange Rate Volatility, Output Volatility and Openness
Sample of Industrial Countries, 1960-2002
Dependent Variable: Standard Deviation of (quarterly) Real Effective Exchange Rate Changes
(\( k = \) number of years)

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<td>Output Volatility</td>
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<td>0.03275 *</td>
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<td>0.02641 *</td>
<td>0.03360 *</td>
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<td>Output Volatility * Openness</td>
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</table>
### Table 3

**Real Exchange Rate Volatility, Monetary Volatility and Openness**

**Sample of Industrial Countries, 1960-2002**

Dependent Variable: Standard Deviation of (quarterly) Real Effective Exchange Rate Changes

(\(k = \) number of years)

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<td>GDP per capita (logs)</td>
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<td>0.00519 **</td>
<td>0.00493 **</td>
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Table 4
Determinants of Real Exchange Rate Volatility
Sample of Industrial Countries, 1960-2002
Dependent Variable: Standard Deviation of (quarterly) Real Effective Exchange Rate Changes
(k = number of years)

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<td>Output Volatility</td>
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<td>Output Volatility * Openness</td>
<td>-0.06929 **</td>
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<td>722</td>
<td>722</td>
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<td>0.5029</td>
<td>0.5027</td>
<td>0.5302</td>
<td>0.5282</td>
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Figure 1
Real Exchange Rate Volatility and Openness

\[ y = -0.0054x + 0.0259 \]
\[ R^2 = 0.0144 \]
Figure 2
Real Exchange Rate Volatility and Exchange Rate Regime

\[ y = 0.0061x + 0.0119 \]

\[ R^2 = 0.272 \]
Figure 3
Real Exchange Rate Volatility and Capital Controls

\[ y = 5 \times 10^{-5} x + 0.0235 \]

\[ R^2 = 5 \times 10^{-5} \]
Figure 4
Real Exchange Rate Volatility and Capital Controls

$y = 0.0502x + 0.0232$

$R^2 = 0.0126$