Economic Quarterly—Volume 93, Number 1—Winter 2007—Pages 57–76

Exchange Rates and Business Cycles Across Countries

Margarida Duarte, Diego Restuccia, and Andrea L. Waddle

Modern theories of exchange rate determination typically imply a close relationship between exchange rates and other macroeconomic variables such as output, consumption, and trade flows. The intuition behind this relationship is that, in most models, optimization of consumption between domestic and foreign goods implies conditions that equate the real exchange rate between two countries to marginal rates of substitution in consumption.[1] Effectively, these conditions bind exchange rates to other contemporaneous macroeconomic aggregates, implying a close relationship between these variables.[2]

The relationship between exchange rates and macroeconomic variables implied by models of exchange rate determination is weakly supported by the data. For instance, Baxter and Stockman (1989) document that the exchange rate regime has little systematic effect on the business cycle properties of

We are grateful to Juan Carlos Hatchondo, Brian Minton, John Walter, and John Weinberg for comments and suggestions. All errors are our own. This article was written while Margarida Duarte and Diego Restuccia were affiliated with the Federal Reserve Bank of Richmond. They are currently professors in the Department of Economics at the University of Toronto. The views expressed in this article are those of the authors and not necessarily those of the Federal Reserve Bank of Richmond or the Federal Reserve System. E-mail: margarida.duarte@utoronto.ca, diego.restuccia@utoronto.ca, and andrea.waddle@rich.frb.org.

[1] These conditions are central to the equilibrium approach of exchange rates. See, for instance, Stockman (1980, 1987) and Lucas (1982).

[2] Another condition present in many exchange rate models equates marginal rates of substitution of aggregate consumption across countries to the real exchange rate (optimal risk sharing across countries), implying a close relationship between exchange rates and macroeconomic aggregates (see, for instance, Chari, Kehoe, and McGrattan 2002). Nevertheless, the exact relationship between exchange rates and other macroeconomic variables implied by exchange rate models depends on the details of the model. See, for instance, Stockman (1987) and Obstfeld and Rogoff (1995) for an analysis of two benchmark models and Stockman (1998) for a general discussion. For the implications of quantitative models, see, for instance, Kollmann (2001) and Chari, Kehoe, and McGrattan (2002).

macroeconomic aggregates other than nominal and real exchange rates. Given that the magnitude of exchange rate volatility is substantially higher under a flexible exchange rate regime than under a fixed regime, this evidence suggests that the relationship between exchange rates and other macroeconomic variables is weak. Flood and Rose (1995) extend these findings and conclude that the exchange rate "appears to have a life of its own."[3] In their assessment of the major puzzles in international economics, Obstfeld and Rogoff (2000) term the weak relationship between nominal exchange rates and other macroeconomic aggregates found in the data as the "exchange rate disconnect puzzle."[4] In fact, the evidence on the relationship of exchange rates and macroeconomic aggregates is puzzling, not only from the point of view of modern theories, but also from a more intuitive point of view. For many economies, the nominal exchange rate is an important relative price, which affects a wide array of economic transactions. Hence, it is surprising that exchange rates are weakly correlated with real variables when they play an important role in determining relative prices in goods markets.

In this article, we present empirical evidence on the business cycle relationship between exchange rates and macroeconomic aggregates for a set of 36 countries. Our goal is to provide direct evidence on the relationship between exchange rates and other macroeconomic variables that potentially can be used to evaluate the implications of exchange rate models.[5] Open-economy models typically restrict the world economy to two large countries or to a small open economy which interacts with the rest of the world. In reality, however, countries interact with many other countries. As a result, it is not straightforward comparing the implications of models with data. We choose to study the relationship between a country's nominal and real effective exchange rates and its domestic macroeconomic variables. The effective exchange rates of a country are averages of the country's bilateral exchange rates against its trading partners.[6] We use effective exchange rates rather than bilateral rates because, in our view, they provide a better indicator of their role in the economy. Hence, the evidence presented in this article can provide

[3] The difficulty in forecasting exchange rates using standard macroeconomic exchange rate models is also well known. See Meese and Rogoff (1983), who show that a simple random-walk model of exchange rates forecasts as well as do alternative standard macroeconomic exchange rate models.

[4] See Devereux and Engel (2002), Duarte (2003), and Duarte and Stockman (2005) for models that address the exchange rate disconnect puzzle.

[5] Stockman (1998) provides direct evidence on the relationship between bilateral exchange rates and the relative output of the two countries.

[6] The nominal effective exchange rate of a country is defined as a geometric-weighted average of the bilateral nominal exchange rates of the country's currency against the currencies of its trading partners. The real effective exchange rate is defined as a geometric-weighted average of the price level of the country relative to that of each trading partner, expressed in a common currency.

discipline to the implications of open-economy models that capture realistic interactions among countries.

We construct a data set with quarterly data on real macroeconomic aggregates and nominal and real effective exchange rates for 36 countries. We investigate the business cycle properties of effective exchange rates and macroeconomic aggregates for each country in our set. We find that in some developed economies, such as the United States, nominal effective exchange rates exhibit no correlation with macroeconomic aggregates such as output and consumption. However, we find that this behavior is not pervasive across our set of economies. In fact, we find that movements in the nominal effective exchange rate are correlated with movements in other macroeconomic variables in many economies, both developed and developing. Moreover, we find that the contemporaneous cross-correlations between nominal exchange rates and trade flows (exports and imports) are not negligible for the vast majority of countries, including the United States. Finally, we find that exchange rates tend to co-move with gross domestic product (GDP), consumption, investment, and net exports more so in poorer countries.

We also relate the volatility of exchange rates to their co-movement with macroeconomic aggregates and to business cycles. The volatility of exchange rates is much larger in developing economies than in developed countries. The substantial volatility of exchange rates in developing countries is related to the larger volatility of output, consumption, and investment in these countries. Moreover, the volatility of exchange rates is positively associated with the level of co-movement between exchange rates and other variables.

Our findings highlight important differences in the business cycle properties of exchange rates and other variables across developed and developing economies. These differences (both in terms of relative volatilities and the cross-correlations of nominal exchange rates with other aggregates) may reflect systematic differences in their economic structures and/or in the nature of the shocks they face. Understanding the differences in the properties of both exchange rate fluctuations and business cycles between developed and developing economies is an important area for further research.

This article is organized as follows. In the next section, we describe the construction of the data set. Section 2 presents the main findings about the correlation between exchange rates and other macroeconomic variables across our sample of countries. In Section 3, we relate the correlation of exchange rates and macroeconomic variables to the volatility level of exchange rates and other standard business cycle statistics. We conclude in Section 4.

1. DATA

We construct a data set with quarterly data on GDP, private consumption, investment, exports, imports, and nominal and real effective exchange rates for a set of 36 countries. The time period varies across countries but all have data for at least ten years. Table 1 lists the countries included in our data set, the data sources, and the sample period.[7] The column for data sources has three entries: the first refers to the data source for GDP and its components, while the second and third refer to the data source for the nominal and real effective exchange rates. Following the income classification of the World Bank for 1998, our sample of countries includes middle- and high-income economies. We associate high-income countries with developed economies and middle-income countries with developing economies. Specifically, in our sample, 19 countries are developed economies and 17 countries are developing economies.[8]

The series for GDP and its components were collected from three sources: International Financial Statistics (IFS), Haver Analytics (HA), and the Economic Commission for Latin America and the Caribbean (CEPAL). The series for investment is gross fixed-capital formation. Some data sources do not provide seasonally adjusted data or data at constant prices, or both. Where needed, we seasonally adjusted the series using the X-12 ARIMA routine from the Census Bureau. When the series for GDP and its components were not available at constant prices, they were converted into real values using the GDP deflator. The series for net exports is constructed as the ratio of the difference between real exports and real imports to real GDP. Effective exchange rates were collected from three sources: IFS, Global Insight (GI), and the Bank for International Settlements (BIS). Both real and nominal effective exchange rates are expressed in quarterly averages and an increase in the exchange rate index reflects an appreciation of the currency. We took the log of all series (except net exports) and applied the Hodrick-Prescott filter (with smoothing parameter 1,600) to each series.[9]

2. EXCHANGE RATES AND REAL AGGREGATES

In this section, we document the cyclical co-movement between nominal effective exchange rates and real aggregates in our data set of 36 countries. We also document the relationship between nominal and real exchange rates and the relationship between real exchange rates and aggregate variables. We conclude this section by relating the degree of co-movement between

---

[7] We ended the sample period in 1998:Q4 for the European countries in our data set that adopted the euro in 1999.

[8] The set of developed economies includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Hong Kong, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. The set of developing economies includes Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Hungary, Malaysia, Mexico, Philippines, Poland, South Africa, Taiwan, Thailand, Turkey, and Uruguay.

[9] The Hodrick-Prescott filter is used to obtain the cyclical component of each time series, that is, fluctuations about trend.

Table 1 Data Sources

Country	Sources	Sample Period
Argentina	HA, GI, BIS	1994:Q1–2005:Q4
Australia	IFS, IFS, IFS	1980:Q1–2005:Q4
Austria	IFS, IFS, IFS	1975:Q1–1998:Q4
Belgium	IFS, IFS, IFS	1980:Q1–1998:Q4
Bolivia	HA, IFS, IFS	1990:Q1–2005:Q4
Brazil	CEPAL, GI, BIS	1994:Q1–2005:Q4
Canada	IFS, IFS, IFS	1975:Q1–2005:Q4
Chile	IFS, IFS, IFS	1996:Q1–2005:Q4
Colombia	CEPAL, IFS, IFS	1994:Q1–2005:Q4
Costa Rica	CEPAL, IFS, IFS	1991:Q1–2005:Q4
Denmark	IFS, IFS, IFS	1977:Q1–2005:Q4
Ecuador	HA, IFS, IFS	1990:Q1–2005:Q4
Finland	IFS, IFS, IFS	1975:Q1–1998:Q4
France	IFS, IFS, IFS	1980:Q1–1998:Q4
Hong Kong	HA, IFS, IFS	1975:Q1–2005:Q4
Hungary	HA, IFS, IFS	1995:Q1–2005:Q4
Italy	IFS, IFS, IFS	1980:Q1–1998:Q4
Japan	IFS, IFS, IFS	1980:Q1–2005:Q4
Malaysia	IFS, IFS, IFS	1991:Q1–2005:Q4
Mexico	CEPAL, GI, BIS	1994:Q1–2005:Q4
the Netherlands	IFS, IFS, IFS	1977:Q1–1998:Q4
New Zealand	IFS, IFS, IFS	1987:Q2–2005:Q4
Norway	IFS, IFS, IFS	1975:Q1–2005:Q4
Philippines	HA, IFS, IFS	1981:Q1–2005:Q4
Poland	IFS, IFS, IFS	1995:Q1–2005:Q4
Portugal	IFS, IFS, IFS	1988:Q1–1998:Q4
South Africa	IFS, IFS, IFS	1975:Q1–2005:Q4
Spain	IFS, IFS, IFS	1980:Q1–1998:Q4
Sweden	IFS, IFS, IFS	1980:Q1–2005:Q4
Switzerland	IFS, IFS, IFS	1975:Q1–2005:Q4
Taiwan	HA, GI, GI	1994:Q1–2005:Q4
Thailand	HA, GI, BIS	1994:Q1–2005:Q4
Turkey	HA, GI, GI	1987:Q1–2002:Q1
United Kingdom	IFS, IFS, IFS	1975:Q2–2005:Q1
United States	IFS, IFS, IFS	1980:Q1–2005:Q4
Uruguay	CEPAL, IFS, IFS	1988:Q1–2005:Q4

Notes: BIS—Bank for International Settlements; CEPAL—Economic Commission for Latin America and the Caribbean; GI—Global Insight; HA—Haver Analytics; IFS—International Financial Statistics.

nominal exchange rates and other macroeconomic variables with the degree of openness to trade and income in each country.

Columns 1 to 6 of Table 2 report the cross-correlations between a country's nominal effective exchange rate and GDP, consumption, investment, trade flows, and net exports for all countries in our data set. We note that the cross-correlations between nominal exchange rates and output, consumption, investment, and net exports reported in this table are low for a few developed

Table 2 Cross-Correlations of Nominal Exchange Rates

Country	(1) $\rho(e,y)$	(2) $\rho(e,c)$	(3) $\rho(e,I)$	(4) $\rho(e,x)$	(5) $\rho(e,m)$	(6) $\rho(e,nx/y)$	(7) $\rho(e,q)$
Argentina	0.50	0.58	0.54	0.12	0.66	-0.64	0.94
Australia	0.20	-0.24	0.22	-0.46	-0.19	-0.24	0.97
Austria	-0.02	-0.08	-0.12	-0.55	-0.39	-0.07	0.89
Belgium	0.04	0.25	-0.27	0.15	0.16	-0.02	0.91
Bolivia	-0.26	-0.23	-0.43	0.14	-0.33	0.36	-0.21
Brazil	-0.29	-0.19	-0.06	-0.44	0.03	-0.44	0.22
Canada	-0.15	-0.33	0.03	-0.39	-0.42	0.11	0.79
Chile	0.47	0.20	0.17	-0.12	-0.06	0.01	0.99
Colombia	0.38	0.44	0.23	0.11	0.50	-0.45	0.97
Costa Rica	0.09	0.47	0.23	-0.31	0.07	-0.32	0.54
Denmark	0.18	0.32	0.31	-0.65	-0.52	-0.21	0.95
Ecuador	0.63	0.69	0.56	-0.12	0.54	-0.49	0.75
Finland	0.50	0.36	0.64	-0.24	0.07	-0.30	0.78
France	-0.31	-0.06	-0.03	-0.68	-0.58	-0.12	0.96
Hong Kong	-0.19	-0.12	-0.03	-0.32	-0.34	0.03	0.74
Hungary	0.18	0.55	-0.19	-0.58	-0.28	-0.27	0.79
Italy	0.08	0.10	0.29	-0.67	-0.39	-0.32	0.97
Japan	-0.34	-0.35	-0.26	-0.64	-0.59	0.17	0.96
Malaysia	0.54	0.76	0.65	-0.44	0.08	-0.63	0.99
Mexico	0.71	0.82	0.75	-0.46	0.72	-0.91	0.94
the Netherlands	-0.17	0.09	-0.05	-0.69	-0.56	-0.37	0.95
New Zealand	0.54	0.52	0.47	-0.68	-0.54	-0.19	0.99
Norway	-0.16	0.00	0.09	0.02	0.07	-0.09	0.87
Philippines	0.47	0.22	0.43	0.14	0.36	-0.23	0.65
Poland	-0.40	-0.23	-0.31	-0.53	-0.69	0.49	0.93
Portugal	0.14	0.15	0.16	-0.40	-0.16	-0.27	0.91
South Africa	0.22	0.13	0.13	-0.27	-0.06	-0.18	0.90
Spain	0.50	0.43	0.48	-0.28	0.17	-0.38	0.93
Sweden	0.12	-0.08	0.28	-0.49	-0.42	-0.16	0.96
Switzerland	-0.37	-0.43	-0.23	-0.58	-0.49	0.09	0.97
Taiwan	0.18	0.20	0.07	0.20	0.10	0.11	0.68
Thailand	0.55	0.58	0.58	-0.28	0.55	-0.72	0.96
Turkey	0.57	0.61	0.58	-0.28	0.65	-0.69	0.86
United Kingdom	-0.19	-0.12	0.03	-0.55	-0.57	0.24	0.93
United States	-0.03	-0.06	-0.02	-0.29	-0.23	0.04	0.95
Uruguay	0.14	0.14	0.17	0.22	0.19	-0.08	0.56

Notes: $\rho(x, y)$—cross-correlation between x and y; e—nominal effective exchange rate; y—GDP; c—consumption; I—investment; x—exports; m—imports; nx—net exports; q—real effective exchange rate.

economies, such as the United States, Norway, and Austria. For instance, for the United States, these cross-correlations of the nominal exchange rate are all below 10 percent (in absolute value). These low correlations attest to a weak relationship between exchange rates and other macro variables at the business cycle frequency in these countries. However, cross-correlations between nominal exchange rates and other macroeconomic aggregates close to zero are not pervasive across our data set. In fact, for most countries in our data set, nominal exchange rates exhibit substantial cross-correlations with other macroeconomic variables at the business cycle frequency. For example, for Spain, the cross-correlations of the nominal effective exchange rate with GDP, consumption, and investment are all above 40 percent; for the Netherlands, the cross-correlations with imports and exports are both above 50 percent. Interestingly, even for the United States, where the cross-correlations of the exchange rate with GDP, consumption, investment, and net exports are close to zero, the cross-correlations with exports and imports are both above 20 percent (in absolute value).

Another notable feature of Table 2 is the diversity in the way nominal exchange rates co-move with the other macroeconomic variables across countries. For instance, for many countries in our data set, exchange rates co-move the most with trade flows (either exports or imports). Such is the case in the United States, the United Kingdom, Denmark, or the Netherlands, among others. But, in contrast, in some other countries, exchange rates co-move the strongest with other macroeconomic variables such as investment (for example, Finland or Belgium) or output (Spain or Chile, for example). In addition, there is not a systematic pattern for the sign of the co-movement of nominal exchange rates with other macro aggregates across countries. This diversity is an indication that countries are subject to different shocks and/or that the same type of shocks propagate differently in the economy. We conclude from the evidence in Table 2 that there is substantial diversity in the way nominal exchange rates co-move with other macroeconomic aggregates in our data set, and that for many countries the degree of co-movement is not negligible.

The nominal effective exchange rate is a summary measure of the external value of a country's currency, relative to the currencies of its trading partners. The real effective exchange rate adjusts the nominal rate for the relative price level across countries. Therefore, a real exchange rate provides a measure of the purchasing power of a currency abroad relative to its domestic purchasing power. It is, therefore, of interest to know how real exchange rates co-move with aggregate macroeconomic variables.

Column 7 of Table 2 reports the cross-correlations between nominal and real exchange rates in our data set. These correlations are very high (above 90 percent) for several countries such as Chile, Italy, Malaysia, New Zealand, and the United States, among others. Most other countries, however, exhibit a lower degree of correlation between nominal and real effective exchange rates. To illustrate the relationship between nominal and real exchange rates, we derive some analytical expressions focusing on bilateral exchange rates.[10]

[10] In logs, the bilateral real exchange rate between countries A and B is defined as $q_{B,A} \equiv e_{B,A} + pr$, where $e_{B,A}$ denotes the log of the nominal exchange rate between the currencies of countries A and B (expressed as the number of currency units of country B per unit of currency

For bilateral exchange rates, the cross-correlation between (the log of) nominal and real rates is related to the ratio of the standard deviation of nominal and real exchange rates, $\sigma(e)/\sigma(q)$, and the cross-correlation between the nominal exchange rate and the price ratio, $\rho(e, pr)$, and is given by

$$\rho(e, q) = \frac{\sigma(e)}{\sigma(q)} + \rho(e, pr)\frac{\sigma(pr)}{\sigma(q)}.$$

This equation indicates that, for bilateral rates, we should expect the cross-correlation between the nominal exchange rate and the price ratio $\rho(e, pr)$ to be close to zero when $\rho(e, q)$ and $\sigma(e)/\sigma(q)$ are both approximately equal to one.[11] Note that, in this case, a strong cross-correlation between nominal and real exchange rates is associated with a weak co-movement between the nominal exchange rate and the relative price across countries. In addition, we should expect a stronger (negative) cross-correlation $\rho(e, pr)$ when the ratio $\sigma(e)/\sigma(q)$ is larger than $\rho(e, q)$.[12] In this case, a weaker cross-correlation between nominal and real exchange rates is associated with a stronger co-movement between the nominal exchange rate and the relative price across countries.

Figure 1 plots the ratios of the standard deviation of nominal and real effective exchange rates against the cross-correlations between these two variables for all countries in our data set. We find that, for many countries, both variables are close to one and that a ratio $\sigma(e)/\sigma(q)$ above one tends to be associated with a lower cross-correlation between nominal and real exchange rates. Although this figure uses data on effective exchange rates, we argue that it suggests a negative relationship between the degree of co-movement of nominal and real exchange rates and the degree of co-movement of nominal exchange rates and relative price levels. That is, for countries that observe lower correlations between nominal and real rates, movements in the nominal exchange rate are more strongly associated with movements in relative prices across countries (in particular, nominal depreciations of a country's currency are associated with increases in the price level of that country relative to the price level in other countries).

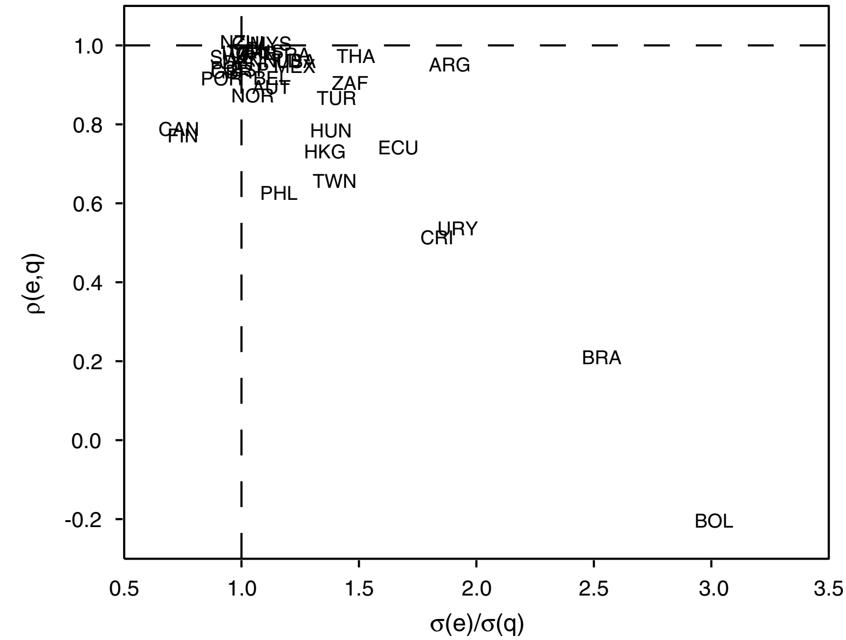
As is the case with nominal exchange rates, low cross-correlations between real effective exchange rates and other macroeconomic variables are not pervasive in our data set. Figure 2 plots the cross-correlation of output

of country A) and pr denotes the log of the consumer price level in country A relative to that of country B.

[11] Intuitively, changes in the price ratio are small and changes in the real exchange rate closely track changes in the nominal exchange rate (i.e., the cross-correlation between nominal and real exchange rates is close to one).

[12] When the ratio of the standard deviation of nominal to real exchange rates is larger than the correlation of nominal and real exchange rates, changes in the real exchange rate do not track changes in the nominal rate as well because nominal exchange rates are negatively correlated with the price ratio across countries.

Figure 1 Nominal and Real Exchange Rates



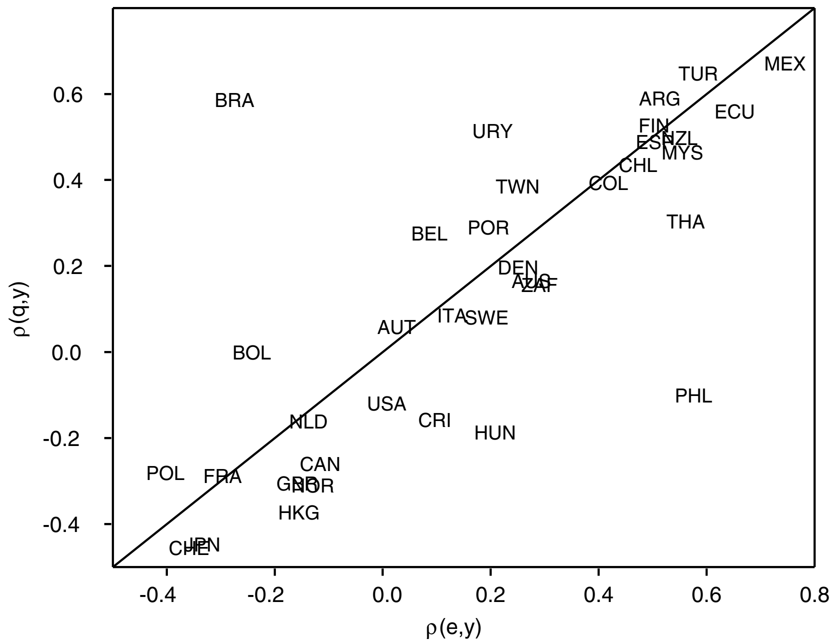
with the nominal exchange rate on the x-axis and with the real exchange rate on the y-axis. For most countries, the two correlations are similar. A similar pattern holds for the cross-correlations of nominal and real exchange rates with other macroeconomic aggregates (see Figure 3). We conclude that in our data set, there is substantial diversity in the way real exchange rates co-move with other macro variables and that for many countries these correlations are not negligible.

Two possible factors behind differences in the co-movement of exchange rates with other variables across countries are the economy's degree of openness and level of development. We now investigate how these two factors relate to the co-movement of the nominal exchange rate with other aggregate variables in our data set.

Exchange Rates and Openness

We construct a measure of the degree of openness of an economy as $\omega \equiv \frac{x+m}{2(y+m)}$, where y denotes GDP, x denotes exports, and m denotes imports. This measure computes the weight of trade relative to the sum of the value of goods produced and imported in an economy. In this formula, the degree of

Figure 2 Correlation of Output with Nominal and Real Exchange Rates

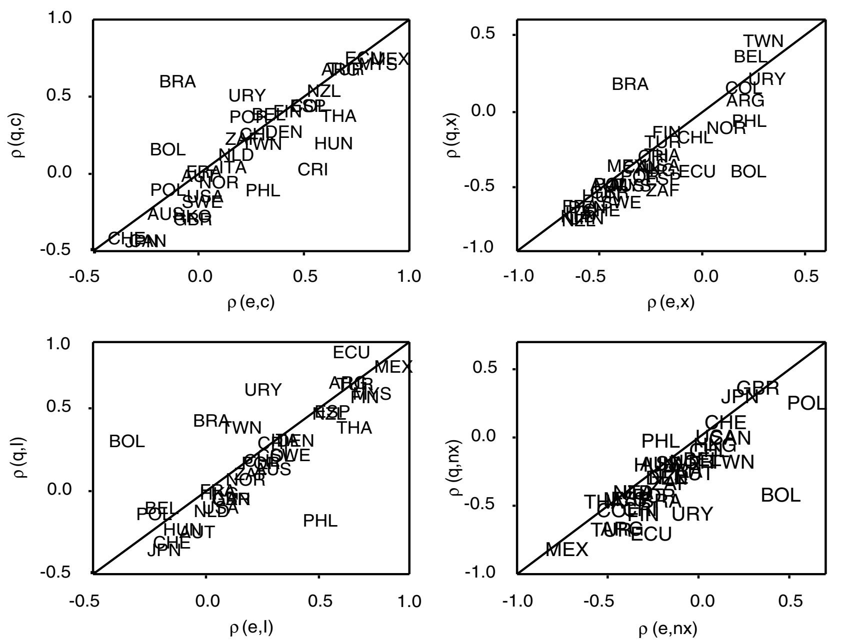


openness of the economy is restricted to between zero and one. The measure of openness is zero when both exports and imports are zero, and it takes the value 0.5 when the value of exports equals output and the value of domestic spending (on consumption and investment) equals imports. The measure of trade approaches one as output and domestic spending (on consumption and investment) approach zero and the value of exports equals the value of imports.

We compute the average value of ω in the sample period of each country using the unfiltered data. This measure varies between 10 and 50 percent in our data set. We find that the weight of trade (as measured by ω) has a weak relationship with the cross-correlation of nominal exchange rates and other macroeconomic aggregates. The correlation coefficients of ω with the (absolute value of the) cross-correlation between nominal exchange rates and GDP, consumption, investment, exports, imports, and net exports are -0.13, 0.12, 0.03, 0.01, -0.18, and -0.10, respectively.[13] That is, in our

[13] We use the absolute value as we are interested in the distinction between a weak relationship of exchange rates with other macroeconomic variables versus a strong relationship (positive or negative). These results are similar to those obtained when the openness measure is given by the ratio $(x + m)/y$.

Figure 3 Correlation of Macroeconomic Aggregates with Exchange Rates



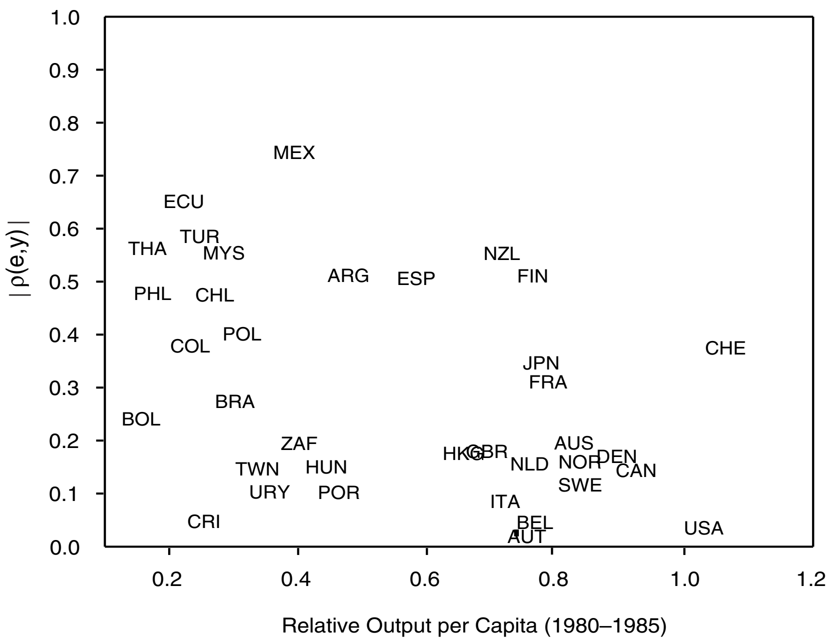
data set, factors other than the weight of trade in the economy are associated with the degree of co-movement of nominal exchange rates with other macro variables.

Exchange Rates and Wealth

Figure 4 plots the absolute value of the cross-correlation between the nominal exchange rate and output against a measure of the country's relative wealth. The wealth measure we use is average GDP per capita relative to that of the United States between 1980 and 1985.[14] There is a negative relationship between our wealth measure and the absolute value of the cross-correlation between the nominal exchange rate and GDP, with a correlation coefficient of -0.46. That is, poorer countries tend to exhibit stronger cross-correlations between the nominal exchange rate and GDP than do richer countries.

[14] We use data on PPP-adjusted GDP per capita, obtained from the Penn World Table Version 6.1 (see Heston, Summers, and Aten 2002).

Figure 4 Correlation Between Nominal Exchange Rate and GDP



Poorer countries also tend to have stronger cross-correlations between the nominal exchange rate and consumption, investment, and the ratio of net exports to GDP. The correlation coefficients between the absolute value of each of these three series and our measure of wealth are −0.41, −0.39, and −0.55. The cross-correlation of the nominal exchange rate and exports tends to vary positively with wealth (correlation coefficient of 0.47), while the cross-correlation with imports does not vary systematically with wealth in our data set (correlation coefficient of 0.08).

We obtain a similar characterization of the relationship between the degree of co-movement of exchange rates with the economy and wealth when we aggregate countries into a group of developed economies and a group of developing economies. Table 3 reports the average cross-correlations of nominal exchange rates across developed and developing economies. The standard error is reported in parentheses. As expected, the cross-correlations of the nominal exchange rate are higher, on average, in developing economies than in developed economies, particularly with respect to output, consumption, investment, and net exports. For example, the average cross-correlation of the nominal exchange rate with output across developing countries is 13 times that of the United States and the average cross-correlation of the nominal

Table 3 Developed Versus Developing Countries

	Developed Economies	Developing Economies
$\rho(e, y)$	0.22 (0.04)	0.39 (0.05)
$\rho(e, c)$	0.22 (0.04)	0.41 (0.06)
$\rho(e, I)$	0.21 (0.04)	0.36 (0.05)
$\rho(e, x)$	0.46 (0.05)	0.28 (0.04)
$\rho(e, m)$	0.36 (0.04)	0.35 (0.06)
$\rho(e, nx/y)$	0.18 (0.03)	0.41 (0.06)
$\rho(e, q)$	0.92 (0.02)	0.76 (0.06)

Notes: See Table 2.

exchange rate with investment across developing countries is 18 times that of the United States.

We should note that several countries in our data set experienced currency crises during the sample period covered. These episodes are characterized by sharp depreciations of the currency that are typically associated with sharp decreases in output, consumption, investment, and a current account reversal. Moreover, in our data set, all currency crises occur in developing economies. We emphasize results for the data set that include currency crises since we do not discriminate across different sources of volatility across countries. Nevertheless, we check whether the relationship between the co-movement of exchange rates and wealth reported previously depends on the occurrence of currency crises in our sample. To this end, we identify all episodes in which the nominal effective exchange rate fell by more than 35 percent within one year. From these episodes, we eliminate from our data set the entire time series for Argentina, Brazil, Ecuador, Malaysia, and Thailand because currency crises occurred in the middle of the sample period for these countries, and the remaining time series was less than ten years long. We reduce the sample period for Mexico, Philippines, South Africa, and Uruguay because currency crises occurred either at the beginning or end of the sample period for these countries, and the reduced sample period was at least ten years long. In this restricted data set, the cross-correlation of the nominal exchange rate with other variables tends to vary with wealth, albeit less than in the original data set. For example, the correlation coefficients between wealth and the cross-correlation of nominal exchange rates with output, consumption, and net exports are -0.24, -0.20, and -0.42. Thus, we conclude that the relationship between wealth and the co-movement of nominal exchange rates with other variables is also present when we restrict the data to exclude currency crises.

Table 4 Exchange Rates and Business Cycles

Country	$\sigma(e)$	$\sigma(y)$	$\sigma(nx/y)$	Relative to $\sigma(y)$		
				$\sigma(c)$	$\sigma(I)$	$\sigma(m)$
Argentina	20.7	5.0	1.9	1.15	3.29	4.09
Australia	6.3	1.4	1.0	0.65	3.84	3.70
Austria	1.8	1.1	1.8	1.50	3.29	4.31
Belgium	3.2	1.3	1.2	0.89	3.34	3.70
Bolivia	8.5	1.3	2.6	1.24	8.81	6.70
Brazil	21.2	1.6	0.8	1.57	3.82	6.26
Canada	3.5	1.5	0.9	0.81	3.29	3.65
Chile	4.8	1.7	1.9	1.13	4.34	3.49
Colombia	6.2	1.9	1.7	1.06	6.61	4.48
Costa Rica	4.1	2.4	4.1	0.67	3.35	3.22
Denmark	2.4	1.5	1.0	1.18	3.89	3.20
Ecuador	17.6	2.1	4.0	1.11	3.98	4.61
Finland	4.8	2.3	1.6	0.65	3.56	3.05
France	2.5	0.8	0.6	1.42	3.82	5.68
Hong Kong	4.7	2.8	1.7	0.99	1.94	1.76
Hungary	3.4	1.0	2.2	2.27	9.03	4.33
Italy	4.0	1.2	0.9	0.99	2.93	4.91
Japan	7.6	1.2	0.5	0.83	2.70	8.41
Malaysia	5.7	2.9	4.7	1.60	4.61	2.38
Mexico	11.1	2.6	1.9	1.21	3.69	2.95
the Netherlands	2.7	1.3	1.1	1.66	3.50	3.85
New Zealand	5.3	1.4	1.3	1.00	4.31	3.29
Norway	2.5	1.7	3.4	1.87	4.57	3.50
Philippines	6.7	2.8	2.4	0.43	5.11	3.04
Poland	5.2	2.0	1.0	1.27	3.46	3.61
Portugal	4.7	1.7	2.4	2.29	5.17	4.39
South Africa	11.7	1.7	2.6	1.57	3.56	5.11
Spain	3.6	1.3	1.0	1.06	3.97	4.03
Sweden	4.3	1.4	0.9	0.98	4.04	3.96
Switzerland	3.8	1.3	1.0	0.70	3.97	4.04
Taiwan	2.9	1.7	1.5	0.69	4.30	3.38
Thailand	6.7	3.8	4.2	1.07	3.82	2.62
Turkey	11.9	3.5	3.3	1.11	2.91	3.43
United Kingdom	4.8	1.4	0.9	1.11	3.44	4.15
United States	5.2	1.3	0.4	0.81	2.75	3.70
Uruguay	13.2	4.1	2.8	1.49	3.30	2.54

Notes: $\sigma(x)$—standard deviation of x. See also Table 2.

3. EXCHANGE RATES AND BUSINESS CYCLES

We have focused on the contemporaneous business cycle movements between exchange rates and other macroeconomic variables across countries. In this section, we document the level of fluctuations of exchange rates across countries and relate these observations to the correlation of exchange rates with other macroeconomic variables and the level of business cycle fluctuations of macroeconomic aggregates.

Table 5 Business Cycles Across Developed and Developing Economies

	Developed Economies	Developing Economies
$\sigma(e)$	3.9 (0.35)	9.5 (1.42)
$\sigma(q)$	4.0 (0.37)	6.4 (0.74)
$\sigma(y)$	1.4 (0.10)	2.5 (0.26)
$\sigma(nx/y)$	1.2 (0.15)	2.6 (0.28)
$\sigma(c)/\sigma(y)$	1.0 (0.07)	1.2 (0.10)
$\sigma(I)/\sigma(y)$	3.5 (0.15)	4.6 (0.45)
$\sigma(m)/\sigma(y)$	4.0 (0.30)	3.9 (0.30)

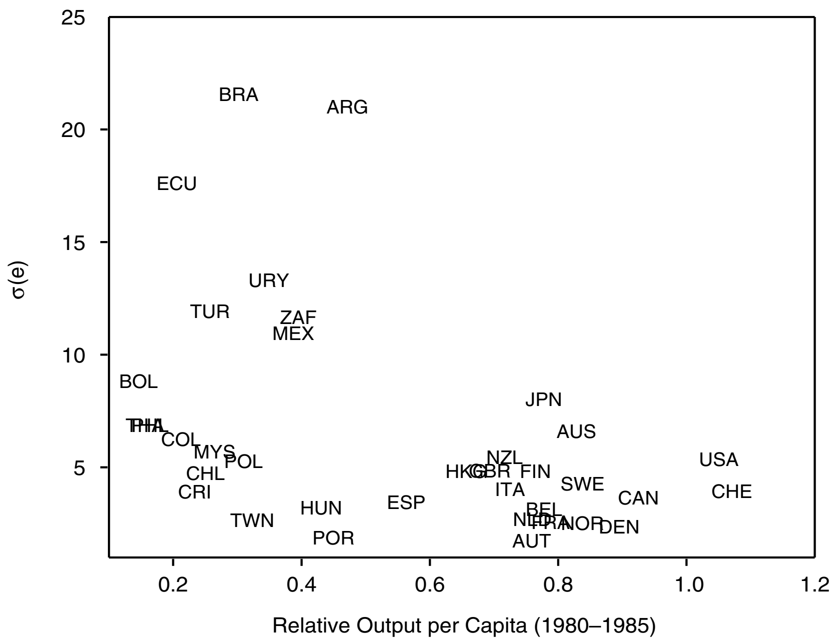
Notes: See Table 2.

Table 4 reports business cycle statistics for all countries in our sample and Table 5 reports the averages of those statistics across developed and developing economies (standard errors are reported in parentheses). One remarkable feature of exchange rate movements across countries is that poorer countries tend to observe much larger fluctuations in the nominal exchange rate than do richer countries (see Figure 5). For instance, in our panel data, the average absolute volatility of the nominal exchange rate is 4 percent across developed countries and more than twice that rate in developing countries, 9.5 percent. Among the developing countries, the highest fluctuations in the exchange rate are observed by Brazil (21.2 percent), Argentina (20.7 percent), Ecuador (17.6 percent), and Uruguay (13.2 percent). The volatility of exchange rates in these countries is substantially larger than the average of 4 percent in developed countries. The highest fluctuations in exchange rates among the developed countries are observed by Japan (7.6 percent), Australia (6.3 percent), and the United States (5.2 percent). Developing countries also tend to observe larger fluctuations in the real exchange rate relative to developed countries.[15] However, we find that for lower levels of absolute volatility, nominal and real rates tend to exhibit similar levels of volatility, while for higher levels of absolute nominal volatility, real exchange rates tend to be substantially less volatile than nominal rates (see Figure 6). Therefore, in developed economies, nominal and real exchange rates exhibit similar levels of absolute volatility, and in developing countries the volatility of real exchange rates is, on average, lower than the volatility of the nominal exchange rate.

The volatility of exchange rates relates systematically to the volatility of other macroeconomic variables. In addition to the higher volatility of exchange rates, poorer countries also tend to present more volatile business cycles with larger fluctuations in output, consumption, investment, trade flows, and net exports. The average absolute volatility of GDP is 2.5 percent in

[15] Hausmann, Panizza, and Rigobon (2006) report this fact using annual data.

Figure 5 Volatility of Exchange Rates and GDP per Capita



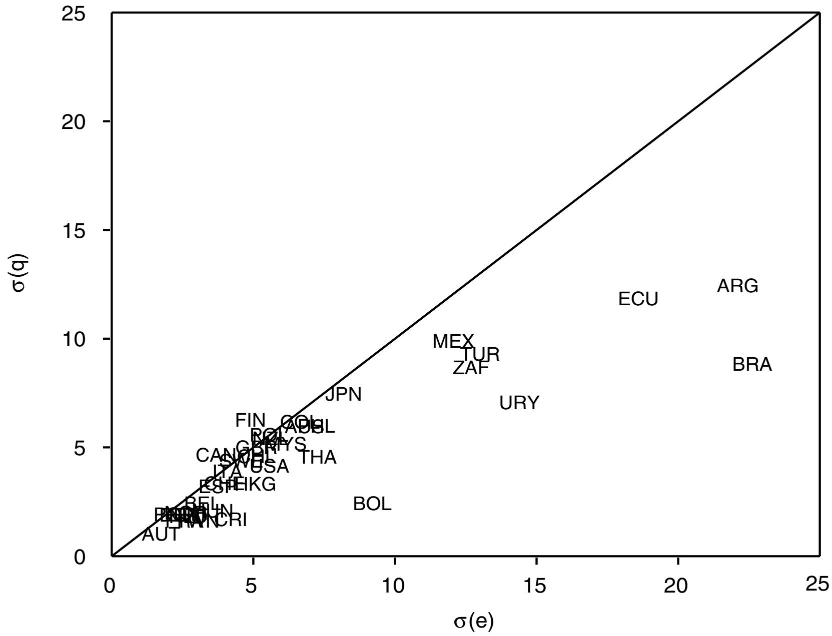
developing countries and 1.4 percent in developed countries. Relative to GDP, the volatility of consumption and investment is higher in developing countries than in developed economies.[16] It is interesting to note that, relative to GDP, the volatility of the real exchange rate is about the same in developed and developing countries (2.9 and 2.8, respectively). This finding is consistent with the fact that developing countries tend to have more volatile nominal exchange rates and that, as we saw previously, real exchange rates tend to be substantially less volatile than nominal rates for these countries.

We relate the absolute volatility of exchange rates to the correlation of exchange rates and macroeconomic aggregates at the business cycle frequency. Figure 7 documents this relationship for GDP, where we separated developed and developing economies into two panels. The correlation coefficient between the two variables is 43 percent for all economies, 33 percent among developed economies, and 25 percent among developing economies.[17] A

[16] For related evidence, see Aguiar and Gopinath (2007).

[17] The relationship between exchange rate volatility and the co-movement of the nominal exchange rate and other macroeconomic variables does not depend on the occurrence of currency crises in our data set. For the reduced sample that excludes currency crises (described in the previous section), we find that the correlation coefficients between $\sigma(e)$ and the absolute value of

Figure 6 Standard Deviation of Nominal and Real Exchange Rates



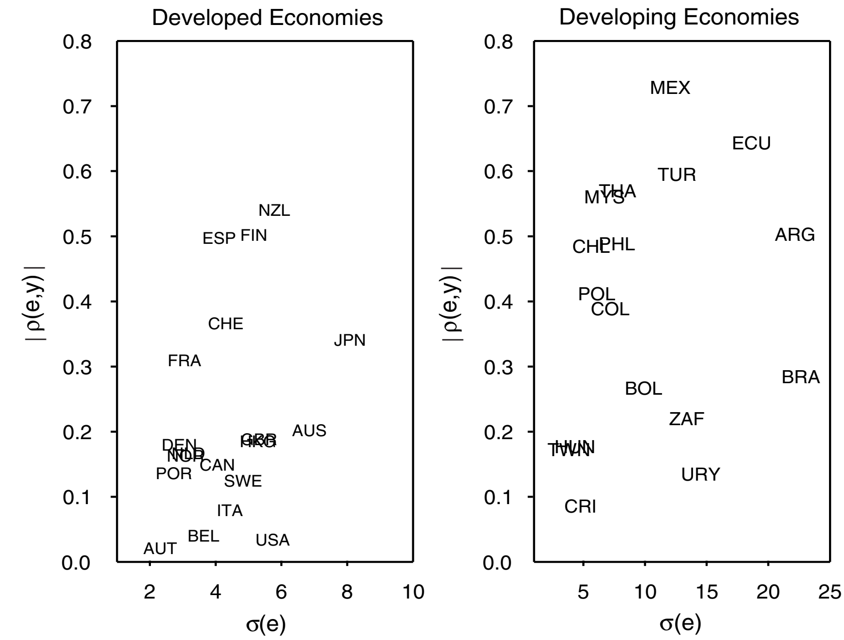
similar correlation emerges for other macroeconomic variables: 48 percent for net exports, 35 percent for consumption, and 32 percent for investment.

The differences in international business cycles across developed and developing economies (both in terms of relative volatilities and the cross-correlations of nominal exchange rates with other aggregates) may reflect systematic differences in their economic structures and/or in the nature of the shocks they face. For instance, Da Rocha and Restuccia (2006) study the business cycle implications of countries that have different economic structures but face the same sectoral shocks. In particular, these authors study economies that differ in the relative importance of agriculture in the economy. Da Rocha and Restuccia (2006) show that differences in the share of agriculture in the economy can account for a large portion of the differences in business cycle statistics across countries.[18] An alternative possibility is that countries face different shocks. Aguiar and Gopinath (2007) abstract from differences in the

$\rho(e, y)$ are 35 percent for all economies, 33 percent for developed economies, and 34 percent for developing economies.

[18] See also Conesa, Díaz-Moreno, and Galdón-Sánchez (2002) for a study in which economies differ in the size of the informal sector.

Figure 7 Correlation Between Nominal Exchange Rate and GDP



economic structure across countries and instead study differences in the nature of exogenous real shocks between emerging and developed economies. In particular, Aguiar and Gopinath (2007) find that emerging economies face shocks to the growth rate of total factor productivity, while developed economies face shocks to the level of total factor productivity. Using the same economic framework in which these different shocks propagate in the economy, Aguiar and Gopinath (2007) find that differences in the nature of shocks account for a large portion of the business cycle differences across emerging and developed economies. Understanding the differences in both exchange rate fluctuations and business cycles between developed and developing economies is an important area for further research.

4. CONCLUSION

We documented the cyclical behavior of exchange rates and real macroeconomic aggregates for 36 economies. While in some economies (such as the United States), contemporaneous business cycle movements in the exchange rate are not correlated with movements in other macroeconomic aggregates, this behavior is not pervasive across all economies in our sample. Moreover, we found that the cross-correlations between nominal effective exchange rates and trade flows (exports and imports) are not negligible for the vast majority of countries, including the United States. The volatility of exchange rates is more than twice as large in developing economies than in developed economies, and we found this volatility to be related to standard business cycle properties and the level of co-movement with other macroeconomic aggregates.

In this article, we studied direct evidence on exchange rates and other aggregate variables and found that negligible cross-correlations between these variables are not pervasive in our data set. In contrast, Baxter and Stockman (1989) and Flood and Rose (1995) use evidence on the business cycle properties of macroeconomic aggregates across exchange rate regimes and conclude that the relationship between exchange rates and other macroeconomic aggregates is weak. Reconciling our findings with those in Baxter and Stockman (1989) and Flood and Rose (1995) remains an open question.

REFERENCES

Aguiar, Mark, and Gita Gopinath. 2007. "Emerging Market Business Cycles: The Cycle is the Trend." *Journal of Political Economy* 115 (1): 69–102.

Baxter, Marianne, and Alan C. Stockman. 1989. "Business Cycles and the Exchange-Rate Regime: Some International Evidence." *Journal of Monetary Economics* 23 (3): 377–400.

Chari, V. V., Patrick J. Kehoe, and Ellen R. McGrattan. 2002. "Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates?" *Review of Economic Studies* 69 (3): 533–63.

Conesa, Juan, Carlos Díaz-Moreno, and José Galdón-Sánchez. 2002. "Explaining Cross-Country Differences in Participation Rates and Aggregate Fluctuations." *Journal of Economic Dynamics and Control* 26 (2): 333–45.

Da Rocha, José M., and Diego Restuccia. 2006. "The Role of Agriculture in Aggregate Business Cycles." *Review of Economic Dynamics* 9 (3): 455–82.

Devereux, Michael, and Charles Engel. 2002. "Exchange Rate Pass-Through, Exchange Rate Variability, and Exchange Rate Disconnect." *Journal of Monetary Economics* 49 (5): 913–40.

Duarte, Margarida. 2003. "Why Don't Macroeconomic Quantities Respond to Exchange Rate Variability?" *Journal of Monetary Economics* 50 (4): 889–913.

Duarte, Margarida, and Alan C. Stockman. 2005. "Rational Speculation and Exchange Rates." *Journal of Monetary Economics* 52 (1): 3–29.

Flood, Robert, and Andrew Rose. 1995. "Fixing Exchange Rates: A Virtual Quest for Fundamentals." *Journal of Monetary Economics* 36 (1): 3–37.

Hausmann, Ricardo, Ugo Panizza, and Roberto Rigobon. 2006. "The Long-Run Volatility Puzzle of the Real Exchange Rate." *Journal of International Money and Finance* 25 (1): 93–124.

Heston, Alan, Robert Summers, and Bettina Aten. 2002. PennWorld Table Version 6.1. Center for International Comparisons at the University of Pennsylvania (CICUP). Available at: http://pwt.econ.upenn.edu. (accessed on May 17, 2006).

Kollmann, Robert. 2001. "The Exchange Rate in a Dynamic-Optimizing Business Cycle Model with Nominal Rigidities: A Quantitative Investigation." *Journal of International Economics* 55 (2): 243–62.

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

Meese, Richard, and Kenneth Rogoff. 1983. "Empirical Exchange Rate Models of the Seventies: Are Any Fit to Survive?" *Journal of International Economics* 14 (1–2): 3–24.

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

Obstfeld, Maurice, and Kenneth Rogoff. 2000. "The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?" In *NBER Macroeconomics Annual 2000*, eds. Ben Bernanke and Kenneth Rogoff. Cambridge, MA: MIT Press: 339–90.

Stockman, Alan C. 1980. "A Theory of Exchange Rate Determination." *Journal of Political Economy* 88 (4): 673–98.

Stockman, Alan C. 1987. "The Equilibrium Approach to Exchange Rates." Federal Reserve Bank of Richmond *Economic Review* 73 (2): 12–29.

Stockman, Alan C. 1998. "New Evidence Connecting Exchange Rates to Business Cycles." Federal Reserve Bank of Richmond *Economic Quarterly* 84 (2): 73–89.