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Uncovered Interest Parity in Crisis

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This paper tests for uncovered interest parity (UIP) using daily data for 23 developing and developed countries during the crisis-strewn 1990s. We find that UIP works better on average in the 1990s than in previous eras in the sense that the slope coefficient from a regression of exchange rate changes on interest differentials yields a positive coefficient (which is sometimes insignificantly different from unity). UIP works systematically worse for fixed and flexible exchange rate countries than for crisis countries, but we find no significant differences between rich and poor countries. [JEL F32, G15]

Uncovered interest parity (UIP) is a classic topic of international finance, a critical building block of most theoretical models, and a dismal empirical failure. UIP states that the interest differential is, on average, equal to the ex post exchange rate change. A strong consensus has developed in the literature that UIP works poorly; it predicts that countries with high interest rates should, on average, have depreciating currencies. Instead, such currencies have tended to appreciate. Surveys are provided by Hodrick (1987), Froot and Thaler (1990), and Lewis (1995). In this short paper, we use recent data for a wide variety of countries to reexamine the performance of UIP during the 1990s.

It is easy to make a case for taking another look at UIP. The vast majority of literature on UIP uses data drawn from low-inflation, floating exchange rate regimes (though our previous work also uses European fixed exchange rate observations;

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see Flood and Rose, 1996). UIP may work differently for countries in crisis, whose exchange and interest rates both display considerably more volatility. This volatility raises the stakes for financial markets and central banks; it also may provide a more statistically powerful test for the UIP hypothesis. UIP may also work differently over time as financial markets deepen; UIP deviations may also vary across countries for the same reason, as recently argued by Bansal and Dahlquist (2000). Finally, and as the proximate motivation for this paper, deviations from UIP are the basis for interest rate defenses of fixed exchange rates. Consider the actions of the monetary authority of a country under speculative pressure that is considering responding with an increase in interest rates—the classic interest rate defense. If UIP holds, the domestic interest rate increase is offset exactly by a larger expected currency depreciation. Investors see through the policy actions, so that no advantage is conferred to domestic securities. Policy-exploitable deviations from UIP are, therefore, a necessary condition for an interest rate defense.

In this short article, we test UIP using recent high-frequency data from a large number of countries. We use data from the 1990s and include all the major currency crises. We find that the old consensus needs updating. While UIP still does not work well, it works better than it used to, in the sense that countries with high interest rates at least tend to have depreciating currencies (though not equal to the interest rate differential). There is a considerable amount of heterogeneity in our results, which differ wildly by country. Some of this is systematic; we find that UIP works worse for fixed-rate countries. There is less heterogeneity by forecasting horizon, however, and almost none by country income.

I. Methodology

We use standard methods (summarized in Flood and Rose, 1996). The hypothesis of uncovered interest parity can be expressed as:

$$\left(1+i_t\right)=\left(1+i_t^*\right)E_t\left(S_{t+\Delta}\right)/S_t, \tag{1}$$

where i_t represents the return on a domestic asset at time t of maturity Δ, i^* is the return on a comparable foreign asset, S is the domestic-currency price of a unit of foreign exchange, and $E_t(.)$ is the expectations operator conditional upon information available at time t.

We follow the literature by taking natural logarithms and ignoring cross terms (most of the countries we consider have only low interest rates). Assuming rational expectations and rearranging, we derive

$$\begin{aligned} &E_t\left(s_{t+\Delta}-s_t\right)\approx\left(i_t-i_t^*\right) \\ &\Rightarrow \left(s_{t+\Delta}-s_t\right)=\alpha+\beta\left(i_t-i_t^*\right)+\varepsilon_t, \end{aligned} \tag{2}$$

where s is the natural logarithm of S, ε_t is minus the forecasting error realized at $t+\Delta$ from a forecast of the exchange rate made at time t, and α and β are regression coefficients. Equation (2) has been used as the workhorse for the UIP literature. The null hypothesis of UIP can be expressed as H_0: $\alpha = 0$, $\beta = 1$, though in practice almost all the focus in the literature has been on β. Since ε_t is a forecasting error, it is assumed to be stationary and orthogonal to information available at time t (including interest rates). Ordinary least squares is, therefore, a consistent estimator of β; it is the standard choice in the literature, and we follow this practice. Researchers have typically estimated β to be significantly negative. Usually α is found to be nontrivial.[1]

In practice, we modify testing (2) in two slight ways. First, we pool data from a number of countries, an admissible way of increasing the sample under the null hypothesis.[2] Second, we use daily data for exchange rate forecasts of up to one quarter of a year. The fact that Δ is greater than unity induces ε to have a moving-average, "overlapping observation" structure. We account for this by estimating our covariance matrices with the Newey and West (1987) estimator, with an appropriate (Δ) number of off-diagonal bands.

II. The Data Set

We are interested in studying how UIP performs of late in a variety of countries, especially those suffering from currency crises during the 1990s. These crises were usually surprising events requiring quick policy responses.[3] In this spirit, we study the crises using a high-frequency, cross-country data set. High-frequency data is of special importance to us given our focus on the interest rate defense of fixed exchange rates.

We gathered daily data for the interest and exchange rates of 23 countries during the 1990s. Our sample includes 13 developed countries (Australia, Canada, Denmark, Finland, France, Germany, Italy, Japan, Norway, Sweden, Switzerland, the United Kingdom, and the United States). We choose these countries to allow us to examine a variety of exchange rate regimes ranging from floating (Australia and Canada) to countries such as Germany and France that are European Monetary System (EMS) participants and have joined the European Economic and Monetary Union (EMU). A number of these developed countries also experienced currency crises in the 1990s, including Finland, Italy, Sweden, and the United Kingdom. We include also data for 10 important and interesting developing countries (Argentina, Brazil, the Czech Republic, Hong Kong SAR, Indonesia, Korea, Malaysia, Mexico, Russia, and Thailand). The crises experienced by these countries account for most of the important action in the 1990s; we include all "the usual suspects." Indeed, it is difficult to think of an important emerging market that did not experience a crisis at some point during the 1990s. Nevertheless, there were considerable periods of tranquility through this period. These, together with

[1]Many have tried to interpret deviations from UIP as risk premiums; here we simply measure UIP deviations carefully and encourage others to link these deviations to other phenomena.

[2]It is likely that many of the countries are receiving correlated shocks, so that a SUR technique (which takes into account this cross-sectional dependence) would result in more efficient estimates; we did this in our 1996 paper. Nevertheless, we do not pursue this angle here, since to use SUR, one has to throw out observations when one or more countries are missing data; this results in a loss of efficiency. Further, the real problem with UIP, at least in our sample, is in the first moment of the data, not the precision of the slope estimates.

[3]See, for example, Rose and Svensson (1994) and Boorman and others (2000).

the many successful and unsuccessful speculative attacks, lead us to believe that our estimates will not suffer from the "peso problem."

Our data are drawn from two sources. (See Table A3 in the appendix for a listing of our data sources by country.) Whenever possible, we use the Bank for International Settlements (BIS) data set. Our default measure of exchange rates is a representative dollar spot rate quoted at 2:15 p.m. Brussels time (BIS mnemonic QBCA). Our default measure of interest rates is a one-month bid rate from the euro money market quoted at about 10:00 a.m. Swiss time (BIS mnemonic JDBA). However, a number of our countries do not have one or both of these series available. Accordingly, we supplement our BIS data with series drawn from Bloomberg. To check the sensitivity of our results with respect to the monthly forecast horizon, we also include interest rate data for three different maturities: one day, one week, and one quarter. Further details and the data set itself are available online at *http://faculty.haas.berkeley.edu/arose/*. The data set has been checked and corrected for errors.

We use the United States as the "center country" for all exchange rates (including that of Germany), except for nine European countries (the Czech Republic, Denmark, Finland, France, Italy, Norway, Sweden, Switzerland, and the United Kingdom), for which we treat Germany as the anchor. We choose our center countries in this way to shed the maximum amount of light on the efficacy of the interest rate defense.

Figure A1 in the appendix contains time-series plots of the exchange rates. The price of a U.S. dollar is portrayed for all countries we studied except for the nine European countries, which portray the price of a deutsche mark. (Scales vary across different plots, as they do in all of the figures.) The breaks in series are usually associated with currency crises or other regime breaks. For instance, the Brazilian exchange rate shows clearly both the adoption of the real after the hyperinflation of the early 1990s and the flotation of the real in January 1999. Similar breaks are apparent for many other countries, including Indonesia, Italy, Korea, Malaysia, Mexico, Russia, and Thailand. The convergence of the EMS rates and the creation of the euro in 1999 are also apparent in the (non-German) EMU rates.

Figure A2 is an analogue showing interest rates. Monthly interest rates are shown for all countries except for Russia (where weekly rates are shown, since the monthly series is short), Finland, and Korea (where quarterly rates are shown for the same reason).[4] Here the currency crises appear as spikes in interest rates. These spikes are particularly obvious during the EMS crisis of 1992–93 (for example, for Denmark, France, Italy, Norway, and Sweden), the Mexico crisis of 1994–95 (for Argentina and Mexico), the Asian crisis of 1997 (for Hong Kong SAR, Indonesia, Korea, Malaysia, and Thailand), and the Russian crisis of 1998. Again, since scales differ, the plots should be interpreted carefully (for example, because of the hyperinflation that preceded the start of the Brazilian *real* plan).

Figure A3 combines the exchange and interest rate data into a single series, which we call "excess returns." Excess returns (*er*) are defined as $[er_{t+\Delta} \equiv (s_{t+\Delta} - s_t) - (i_t - i_t^*)]$, annualized appropriately. Under the UIP null

[4]We define a month as 22 business days, a week as 5 business days, and a quarter as 65 business days.

hypothesis (H_0: $\alpha = 0$, $\beta = 1$) $E_t er_{t+\Delta} = 0$. Again, we use a monthly horizon as our default (so that we use one-month interest rates and set Δ equal to one month); the only exceptions are Russia (for which we use weekly rates and horizon), and Finland and Korea (for which quarterly rates and horizon are used).

In essence, the plots in Figure A3 show the results of taking a short position in the currency. For example, since Argentina did not deviate from its peg with the U.S. dollar, the payoff from attacking the Argentine peso was consistently negative throughout the 1990s, and dramatically so during the interest rate defense against the "tequila" attacks of early 1995. The successful attacks against the Korean won, the Mexican peso, and the Russian ruble show up as large positive payoffs when the currencies were floated.

Where Figure A3 provides a look at a combination of exchange rate changes and interest rate differentials over time, Figure A4 graphs the exchange rate changes and interest rate differentials against each other. Instead of examining the time-series patterns on a country-by-country basis as in Figure A3, we pool the country data. Exchange rate changes (on the ordinate) are more volatile than interest rate differentials (on the abscissa) for each horizon. There clearly is no tight relationship between exchange rate changes and interest differentials. This is no surprise; interest differentials are not very useful in predicting exchange rate changes. Since the visual impression is unclear, we now proceed to more rigorous statistical analysis, which is essentially an analogue to the graphs in Figure A4.

III. UIP Regression Analysis

Table A1 in the appendix provides estimates of β when equation (2) is estimated on a country-by-country basis; that is, the regressions are estimated for an individual country over time. Newey-West standard errors that are robust to both heteroskedasticity and autocorrelation (induced by the overlapping observation problem) are recorded in parentheses below. We focus on the monthly horizon results but also tabulate the results for the three other forecasting horizons as a sensitivity check.

The most striking thing about the estimates of β is their heterogeneity. Of the 21 estimates, 12 are negative and 7 are positive (2 are essentially zero). This, in itself, is interesting, since virtually all estimates in the literature are negative. Further, all but one of the negative estimates are insignificantly so, while three of the positive coefficients are significant. At conventional significance levels, only nine of the slopes are insignificantly different from the hypothesized value of unity. This is frequently because of large standard errors, however, rather than point estimates close to unity, so even this evidence is weak.[5] Finally, the point estimates vary across forecast horizons, often switching signs.

We do not report estimates of the intercept (α) in Table A1. They are of less interest, and are usually insignificantly different from zero, at conventional confidence levels. For instance, of the 21 intercepts estimated at the monthly horizon, only

[5]Some of the standard errors are very low, however; they may be biased because of non-normalities associated with jumps at currency crises. Hence we recommend that readers not take our covariance estimates too literally.

2 are significant at conventional significance levels: Canada (with a positive intercept and a t-statistic of 2.1) and Japan (with a negative intercept and a t-statistic of 2.0).

Table A2 pools the data across countries, so that a single β is estimated for all countries and periods of time. Here, too, the results are striking. In particular, the top panel shows that the pooled estimate is positive at all four horizons. At the monthly horizon, β is significantly positive, though at 0.19 it is far below its theoretical value of unity. At the other horizons, β is even higher and insignificantly different from unity (and strikingly close to unity, though with large standard errors, when daily and weekly horizons are used).[6] Still, pooling is a dubious procedure given the heterogeneity manifest in Table A1, so we do not take these results too seriously.[7]

The other panels of Table A2 add interactions between dummy variables and the interest differential. Panel B includes an interaction with the exchange rate regime. We consider Argentina, Denmark, France, and Hong Kong SAR to have fixed their exchange rates throughout the sample, while we classify Australia, Canada, Germany, Japan, Norway, and Switzerland as floaters. The other ("crisis") countries experienced at least one regime switch and are omitted from our control group.

We find that both fixers and floaters have significantly lower estimates of β, in contrast to the findings of our earlier study (Flood and Rose, 1996), which used data from the late 1970s through the early 1990s. Thus the marginally better UIP results that stem from pooling across countries must be largely due to the inclusion of countries whose exchange rate parities were successfully attacked.

When we examine interactions between the interest rate differential and a dummy variable that is unity for countries that were members of the Organization for Economic Cooperation and Development at the beginning of the decade, we find insignificantly different results. This result stands in contrast to the estimates provided by Bansal and Dahlquist (2000).[8]

Finally, we dummy out the three countries that experienced high inflation at some point during the sample period (Argentina, Brazil, and Russia). When we do so, we find in Panel D that some of our positive results stem from high-inflation countries; the interaction terms are typically positive and economically large (especially at shorter horizons). However, our point estimates for β are still positive or zero, unlike those in most of the literature (though our standard errors are large).

IV. Conclusion

Uncovered interest parity works better than it used to, in the sense that interest rate differentials seem often to be followed by exchange rate depreciation. The fact that this relationship was positive on average during the 1990s contrasts sharply with the typically negative estimates of the past. When the daily and weekly horizons are used, this relationship even seems to be proportionate if one includes high-

[6] Chinn and Meredith (2000) find even more positive results using long-maturity data.

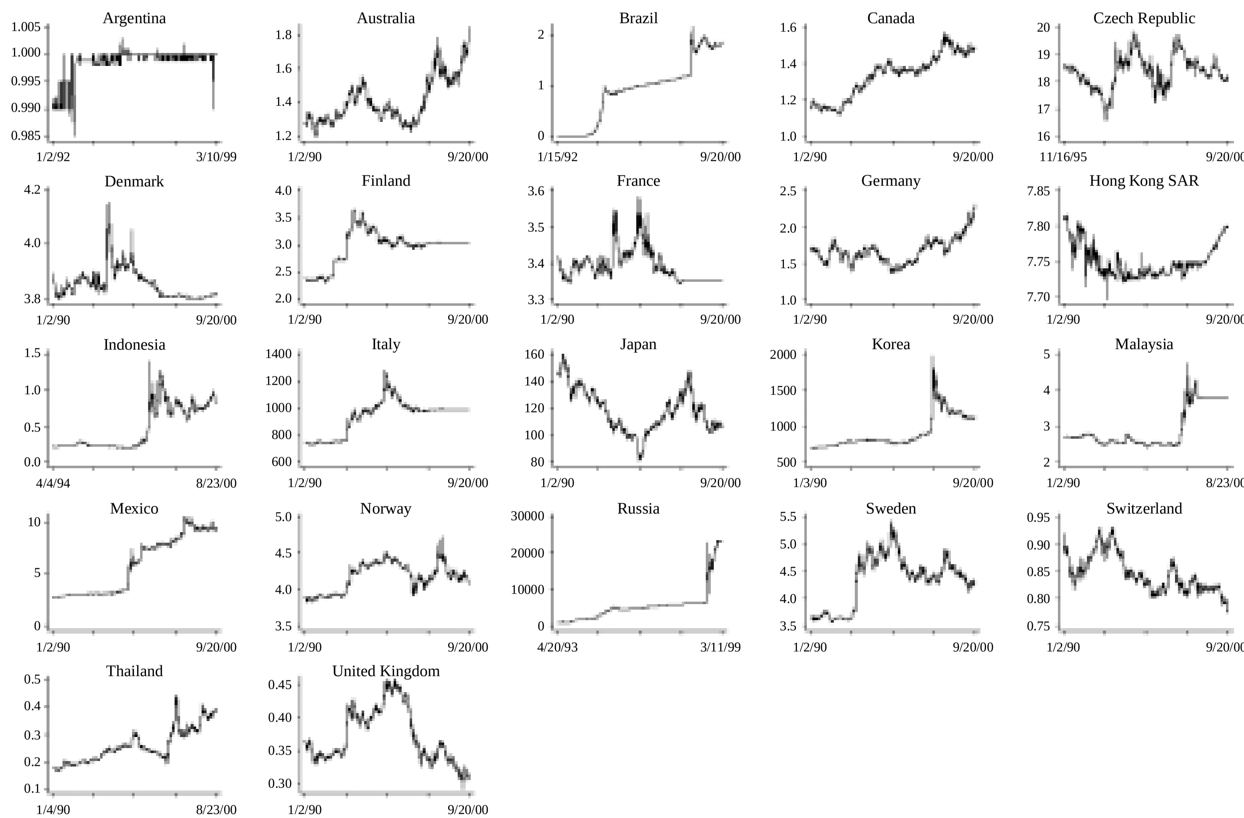
[7] This is especially true since the Hildreth-Houck random-coefficients method delivers slope coefficients that are economically and statistically insignificant on our pooled data.

[8] Our data set is deeper and narrower, focusing on more horizons and daily data instead of the monthly horizon stretching back to 1976 that is employed in Bansal and Dahlquist (2000).

inflation countries. Nevertheless, there are still massive departures from uncovered interest parity. There is enormous heterogeneity in the UIP relationship across countries, though we have been unable to find a close relationship between departures from UIP and either the exchange rate regime or country income.

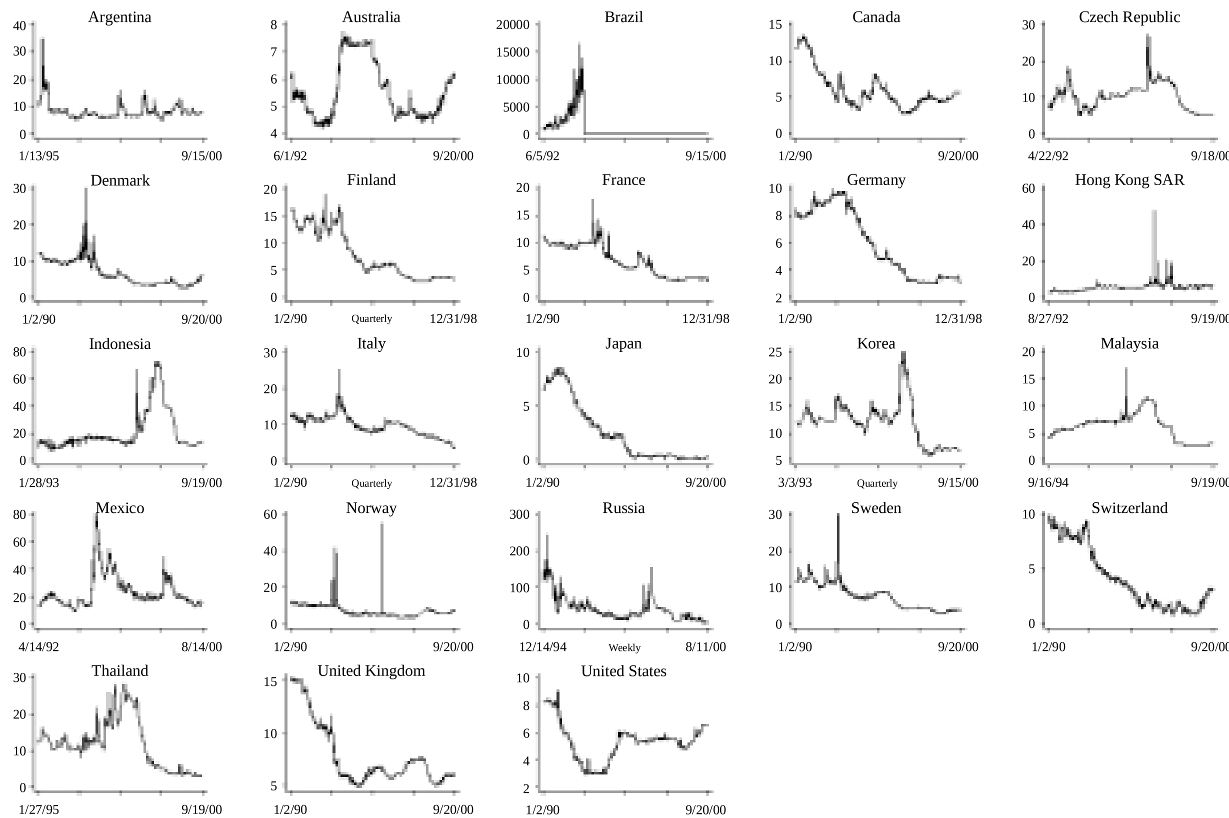
APPENDIX

Figure A1. Twenty-Two Countries: Exchange Rate Fluctuations
(percent)



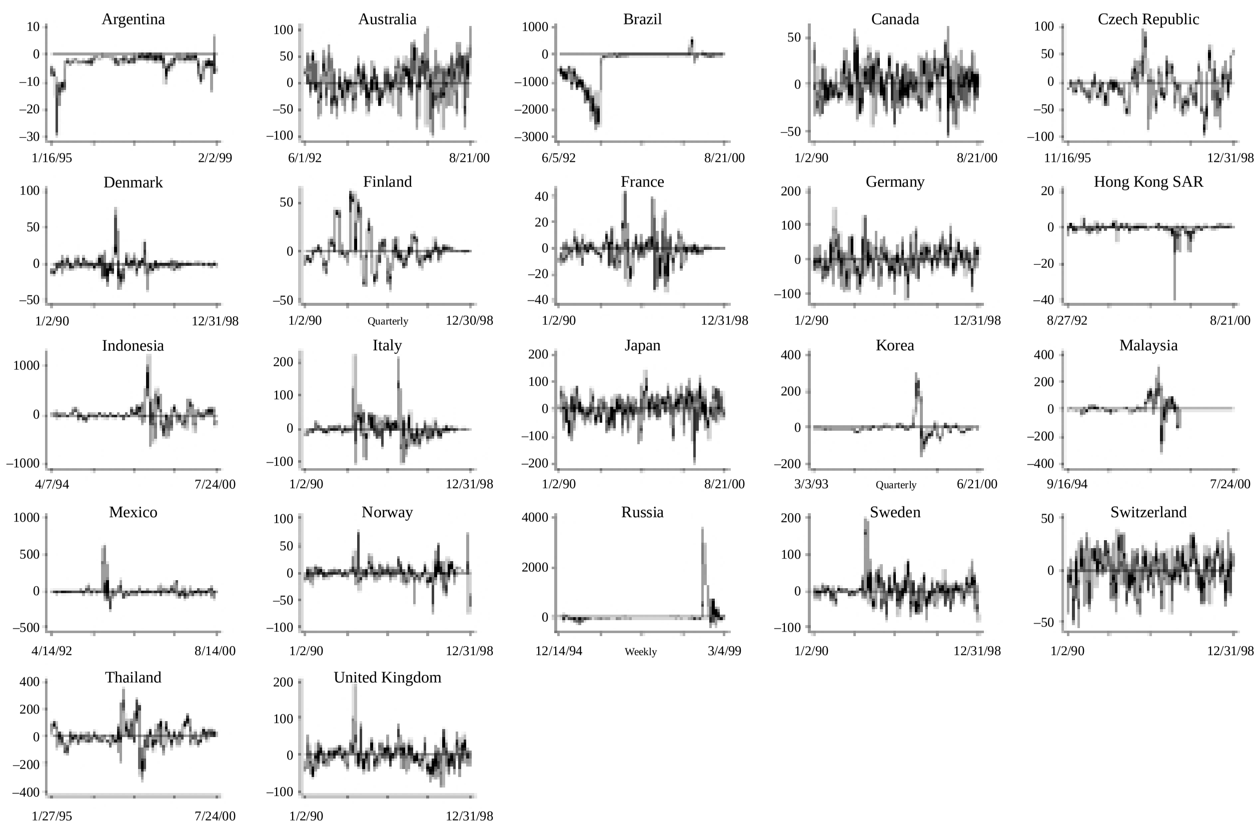
Notes: Scales differ across countries. Dates are listed by month, day, and year: for example, 1/3/90 denotes January 3, 1990.

Figure A2. Twenty-Three Countries: Fluctuations in Monthly[1] Interest Rates
(percent)



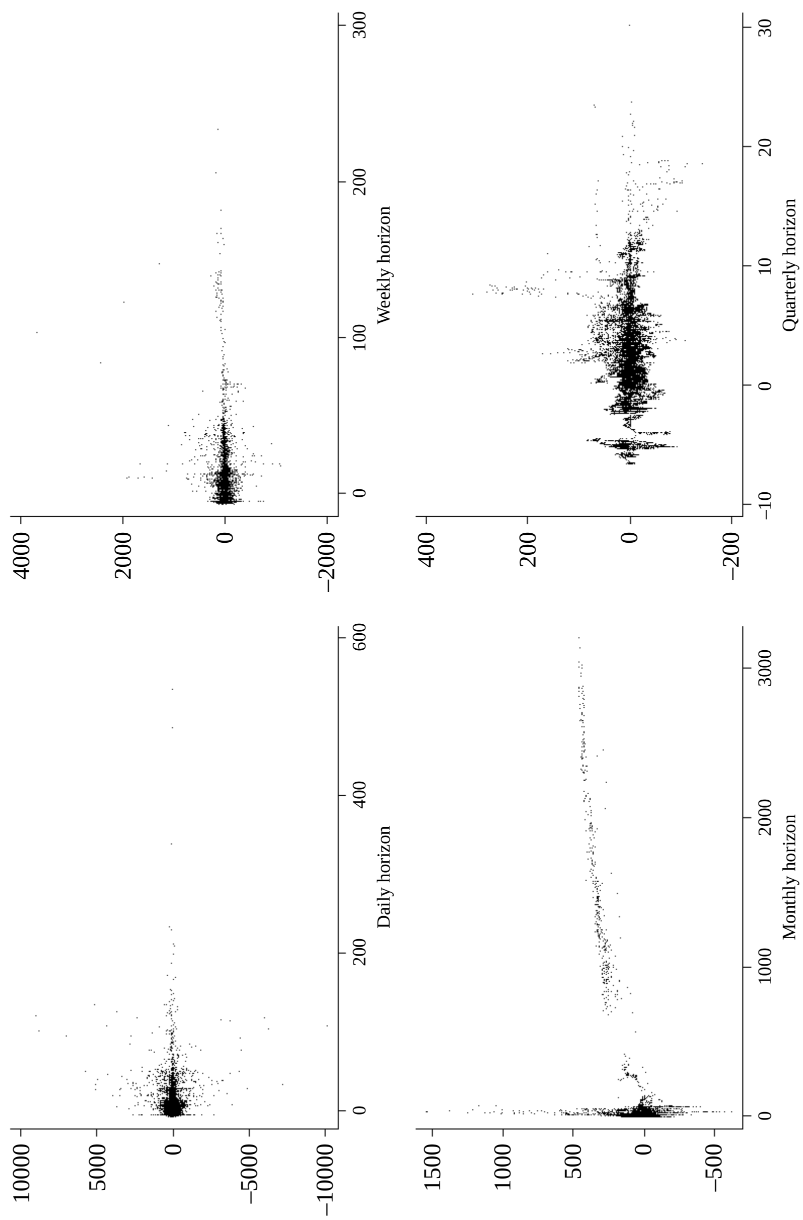
Notes: Scales differ across countries. Dates are listed by month, day, and year: for example, 1/3/95 denotes January 3, 1995.
[1]Except as otherwise shown in individual charts.

Figure A3. Twenty-Two Countries: Fluctuations in Monthly[1] Excess Returns[2]
(percent)



Notes: Scales differ across countries. Dates are listed by month, day, and year: for example, 1/3/95 denotes January 3, 1995.
[1]Except as otherwise shown in individual charts.
[2]Exchange rate change minus interest differential, annualized.

Figure A4. Exchange Rate Changes[1] and Interest Rate Differentials[2] During the 1990s
(annualized percentage changes in daily data)



[1]Measured on the y axis.
[2]Measured on the x axis.

Table A1. Uncovered Interest Parity Tests, by Country

(OLS estimates of β from $(s_{t+\Delta} - s_t) = \alpha + \beta(i - i^*)_t + \varepsilon_t$)

Horizon	Daily	Weekly	Monthly	Quarterly
Argentina	0.03		0.00	–0.003
	(0.11)		(0.01)	(0.002)
Australia			–3.58	
			(2.55)	
Brazil	15.3		0.19	
	(15.9)		(0.01)	
Canada			–0.58	
			(0.54)	
Czech Republic	0.73		–1.27	–1.41
	(1.13)		(0.85)	(1.14)
Denmark			–0.03	
			(0.70)	
Finland	2.50		7.06	2.56
	(2.20)		(3.80)	(1.21)
France			–1.42	
			(0.62)	
Germany	–0.60		0.13	–0.11
	(1.32)		(1.11)	(1.16)
Hong Kong SAR	–0.35	–0.20	0.00	–0.00
	(0.18)	(0.06)	(0.03)	(0.02)
Indonesia	0.22		–1.19	
	(2.05)		(1.13)	
Italy	1.66		0.29	–0.75
	(1.87)		(2.55)	(1.92)
Japan	–0.82	–3.14	–1.71	–1.84
	(1.36)	(1.83)	(1.11)	(1.19)
Korea	3.41	1.42		–0.31
	(4.12)	(2.08)		(1.57)
Malaysia			2.24	2.07
			(2.08)	(1.95)
Mexico	–0.37	–0.60	–0.77	
	(1.00)	(0.66)	(0.70)	
Norway			0.59	
			(0.75)	
Russia	1.48	1.29	0.22	
	(1.46)	(0.58)	(0.11)	
Sweden	0.08		–0.44	1.28
	(0.03)		(0.95)	(2.03)
Switzerland			–2.08	
			(1.40)	
Thailand	0.52	–1.29	–0.83	
	(1.86)	(1.57)	(1.80)	
United Kingdom	–1.15		–1.26	–1.42
	(1.06)		(0.97)	(0.98)

Note: Newey-West standard errors in parentheses.

Table A2. Pooled Uncovered Interest Parity Tests

(OLS estimates of β from $(s_{it+\Delta} - s_{it}) = \alpha + \beta(i - i^{*})_{it} + \varepsilon_{it}$)

Panel A. No Interactions

	β (se)	Number of Observations
Daily	0.86	26,972
	(0.65)	
Weekly	0.87	8,033
	(0.34)	
Monthly	0.19	37,992
	(0.01)	
Quarterly	0.29	18,942
	(0.39)	

Panel B. Exchange Rate Regime Interactions

	β (se)	FIX*β (se)	FLOAT*β (se)	Number of Observations	P-value: Interactions=0
Daily	0.87	–0.94	–0.71	26,972	0.21
	(0.67)	(0.58)	(10.23)		
Weekly	0.92	–0.87	–1.26	8,033	0.00
	(0.37)	(0.29)	(1.40)		
Monthly	0.19	–0.93	–0.20	37,992	0.01
	(0.01)	(0.32)	(0.48)		
Quarterly	0.43	–0.54	–0.47	18,942	0.44
	(0.49)	(0.42)	(0.94)		

Panel C. Country-Income Interactions

	β (se)	OECD*β (se)
Daily	0.97	–0.80
	(0.75)	(0.48)
Weekly	0.92	–1.28
	(0.37)	(1.40)
Monthly	0.19	–0.31
	(0.01)	(0.36)
Quarterly	0.27	0.06
	(0.54)	(0.68)

Panel D. High-Inflation Interactions

	β (se)	High Inflation*β (se)
Daily	0.38	0.89
	(0.47)	(1.22)
Weekly	0.32	0.71
	(0.33)	(0.50)
Monthly	0.00	0.19
	(0.42)	(0.42)
Quarterly	0.31	–0.45
	(0.40)	(0.37)

Note: Newey-West standard errors appear in parentheses.

Table A3. Sources of Exchange Rate and Monthly-Horizon Interest Data

	Exchange Rate Source	Interest Rate Source
Argentina	BIS	Bloomberg
Australia	BIS	BIS
Brazil	Bloomberg	Bloomberg
Canada	BIS	BIS
Czech Republic	BIS	Bloomberg
Denmark	BIS	BIS
Finland	BIS	BIS
France	BIS	BIS
Germany	BIS	BIS
Hong Kong SAR	BIS	Bloomberg
Indonesia	BIS	BIS
Italy	BIS	BIS
Japan	BIS	BIS
Korea	Bloomberg	
Malaysia	BIS	Bloomberg
Mexico	BIS	Bloomberg
Norway	BIS	BIS
Russia	BIS	Bloomberg
Sweden	BIS	BIS
Switzerland	BIS	BIS
Thailand	BIS	Bloomberg
United Kingdom	BIS	BIS
United States		BIS

Note: BIS denotes Bank for International Settlements.

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