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FIXES: OF THE FORWARD DISCOUNT PUZZLE

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ABSTRACT

Regressions of *ex post* changes in floating exchange rates on appropriate interest differentials typically imply that the high-interest rate currency tends to appreciate, the "forward discount puzzle." Using data from the European Monetary System, we find that a large part of the forward discount puzzle vanishes for regimes of fixed exchange rates. That is, deviations from uncovered interest parity appear to vary in a way which is dependent upon the exchange rate regime. By using the many EMS realignments, we are also able to quantify the "peso problem."

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I: Introduction

It is well known that deviations from uncovered interest parity (UIP) are pervasive and persistent.1/ In particular, currencies with high interest rates tend to appreciate relative to those with lower interest rates, contrary to the hypothesis of UIP. Since foreign exchange markets are among the deepest markets in the world, explaining UIP deviations is an interesting and important task for international finance researchers.

In this short paper, we contribute to the literature in two ways. First, we test UIP for fixed exchange rate currencies. Nearly all of the relevant literature has tested (and rejected) UIP using data for floating exchange rates. A typical finding is that the slope coefficient from a regression of the *ex post* change in the exchange rate on the appropriate interest differential is usually negative, economically and statistically far below the UIP value of +1. We find it easy to produce such results using daily data from the 1980s and 1990s pooled across a number of countries which are floating vis-a-vis the American dollar. However, when we use fixed exchange rate data from the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS), we find that UIP fares much better. Instead of being negative, the slope coefficient is typically around +.6, though still significantly below its hypothesized value of unity.

Our second contribution stems from the fact that the ERM has experienced a number of discrete exchange rate realignments (and other such events) since the EMS began in 1979. Many of these realignments were anticipated by the financial markets. Market anticipations of an event which does not occur sufficiently frequently in the sample leads to small-sample bias in UIP regressions. This bias is commonly referred to as the "peso

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1/ Hodrick (1987), Froot and Thaler (1990), and Lewis (1993) provide recent surveys.

problem". We attempt to quantify this bias by pooling our data across currencies, and comparing regression results when the realignments are included in the sample to those when the realignment observations are excluded. While there is no guarantee that the 54 realignments which the ERM experienced in our sample are enough to constitute a large sample (especially as these events are not independent across country or time), our best guess is that the peso problem leads to a bias of around -.35, the difference between the slope coefficient in the UIP regression when the latter is estimated with and without realignments.

In section II of the paper, we describe our data set and empirical methodology. Our empirical results are present and discussed in section III; a brief interpretation concludes.

II: Methodology and Data

The hypothesis of uncovered interest parity can be expressed as:

$$(1+i_t) = (1+i^*_t)E_t(S_{t+\Delta})/S_t \qquad (1)$$

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 $E_t(.)$ represents the expectations operator conditional upon information available at t.

We follow the literature in taking natural logarithms and ignoring small cross terms by considering only countries with "low" interest rates. Rearranging, we derive:

$$E_t(s_{t+\Delta} - s_t) \approx (i\text{-}i^*)_t$$

$$=> \quad s_{t+\Delta} - s_t = \alpha + \beta(i\text{-}i^*)_t + \epsilon_t \tag{2}$$

where: s is the natural logarithm of s; ϵ_t is 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. Since ϵ_t is a forecasting error, it is assumed to be stationary and orthogonal to all information available at time t, including interest rates; hence OLS is a consistent estimator of β.

Equation (2) has been used as the workhorse for most of the extant UIP literature. The null hypothesis of UIP can be expressed as Ho: $\alpha=0$, $\beta=1$. Researchers have typically estimated β to be significantly negative β estimate, and α to be non-trivial.

In practice, we modify (2) in two slight ways. First, we pool together data from a number of different countries, an admissible way of increasing the sample under the null hypothesis. Second, we use data of daily frequency for exchange rate forecasts of usually three months horizon. The fact that Δ is greater than unity induces ϵ to have a moving average "overlapping observation" structure. We take account of this by estimating our covariance matrices with the well-known Newey-West estimator, with an appropriate number of off-diagonal bands.

We estimate (2) on two different data sets: one for flexible exchanges, one for fixed exchange rates. Both data sets consist of daily observations on exchange and interest rates; the data have been check and corrected for various errors.1/

1/ Our data sets and programs are available upon receipt of a self-addressed ready-to-mail package of four formatted high-density IBM diskettes.

Throughout, we use 90-day euro-currency interest rate series, observed at 10:00 am Swiss time. We convert both interest differentials and exchange rate changes to annualized percentages.

Our floating exchange rate data set consists of bilateral dollar rates quoted at noon in London from 1981 through early October 1994 (the sample period was chosen to match the EMS data set relatively closely, subject to restrictions of data availability). We include the following countries, which float more or less cleanly relative to the United States: Australia; Canada; France; Germany; Japan; Switzerland; and the UK.1/

In Figure 1, the 90-day change in the (natural logarithm of the) exchange rate, regressand of equation (2), is plotted (on the ordinate) against the 90-day interest differential (regressor of (2), on the abscissa). The figure, like our statistical work, pools together the observations from all countries and time periods. Figure 1 appears to be a cloud of observations without any clear pattern. There does not appear to be a clear tendency for the observations to be sloped in any particular way.

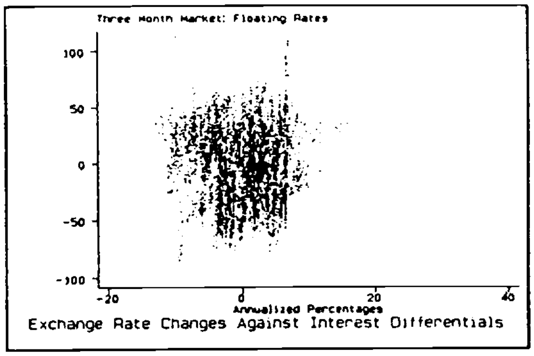

Figure 1: Floating Rate Data

1/ Canada smooths its exchange rate; the European exchange rates are linked through the ERM. These reasons may lead one to believe that there should not be enormous differences between the results from our different data sets. We view the issue as debatable, and try to let the data speak for themselves.

Our "fixed" exchange rate data set covers all members of the ERM from its inception in March 1979 through early March 1994.1/ We treat Germany as the anchor of the ERM, and measure all bilateral rates in DM terms. The other long-term members of the ERM have been: Belgium-Luxembourg; Denmark; France; Ireland; Italy; and the Netherlands. Portugal, Spain, and the UK were later entrants; Italy and the UK left the ERM in mid-September 1992. The exchange rate data are cross-rates derived from dollar rates, observed at 2:15 Swiss time by the BIS at the official "ecu fix". For this data set, we have both 90- and 30-day euro-currency interest rates.

The ERM has experienced a large number of "events" which have affected European exchange rates *ex post*. Counting events for different countries individually, there have been 54 realignments of bilateral DM central parities.2/ Many of these events were anticipated by the financial markets, with varying degrees of accuracy. Comparing estimates of β when (2) is estimated with and without the realignment observations is a simple way to estimate the well-known small-sample peso problem bias. When we exclude observations which include these events, we induce the bias. We hope that inclusion of these observations should remove the peso problem. However, there is no guarantee that our 54 realignments are sufficient to constitute a large sample, since they are not independent events.3/

1/ We recognize that the ERM was not, strictly speaking, a perfectly fixed exchange rate system, since it allowed minor currency fluctuations even for "narrow band" members.

2/ There have also been three entrances into the ERM, two exits from the system, one narrowing of a bandwidth, and a number of widenings of bandwidths. In practice, we ignore the last events, since central DM parity were not changed, and check for the sensitivity of our results with respect to the others.

3/ Since we either include or exclude all of the realignments from the sample, we are really providing a maximal estimate of the peso problem bias.

Our pooled ERM data set is displayed in Figure 2. The top left panel displays the 30-day change in the exchange rate graphed against the corresponding 30-day interest rate

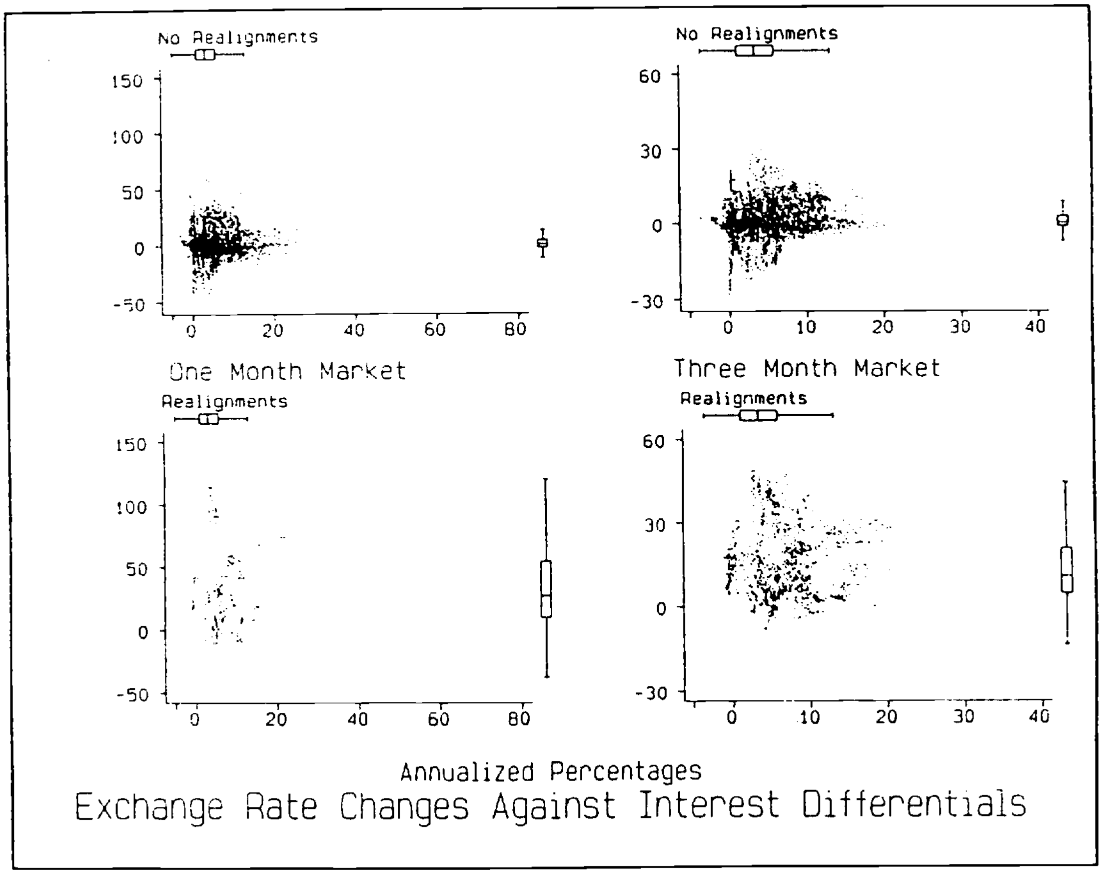

Figure 2: Fixed Rate Data

differential. Only observations which *do not* include an actual ERM realignment are plotted. Immediately below is an exactly comparable graph which displays only observations from the periods which *do* include an ERM realignment. The graphs to the right are analogues for the 90-day market.

Since the data in Figure 2 are sometimes crowded closely together, we also include "box and whisker" plots for the marginal distributions. These are displayed above (for interest differentials) and to the right (for exchange rate changes) of the joint distribution scatterplot. The line in the middle of the box marks the median; the box covers the interquartile range (i.e., from the 25th percentile to the 75th percentile). The whiskers extend to upper and lower "adjacent values"; 150% of the interquartile range rolled back to the nearest data point. Points beyond adjacent values are usually considered to be outliers.

For both the 30- and 90-day markets, the joint distributions for observations without realignments resemble shapeless clouds. However, there are stronger indications of a positive relationship between exchange rate changes and interest differentials for the observations with realignments, particularly in the 90-day market. We now proceed to investigate this hunch with more rigorous statistical analysis.

III: Results

We estimated (2) on our pooled sample of data. Our results are displayed in Table I.

The first lines present estimates from the data set of floating exchange rates. The first line estimates (2) for the entire sample; the second adds country-specific intercepts to the regression specification. Consistent with the findings of the literature, β is estimated to be negative and significantly below its hypothesized value of unity, in both cases. A negative estimate of β is a standard finding in the international finance literature, and constitutes the "forward discount puzzle". This finding implies that there is a non-trivial correlation between ϵ, the disturbance in (2), and the interest differential.

The last lines present estimates from the EMS sample of fixed exchange rate observations. There are four set of estimates: two each from the 30- and 90-day markets. For each maturity, there are two sets of estimates. The first is estimated using the entire

Table I: Estimates of (2)

	β	α	N
Floating-Rate Sample			
Three-Month Equation	-.28 (.33)	-1.08 (1.14)	19,971
Three-Month Equation, country-specific intercepts	-1.07 (.44)	n/a	19,971
Fixed-Rate Sample			
One-Month Equation, including realignments	.58 (.11)	.31 (.43)	22,828
One-Month Equation, excluding realignments	.18 (.05)	.62 (.27)	21,859
Three-Month Equation, including realignments	.58 (.09)	.20 (.39)	22,493
Three-Month Equation, excluding realignments	.25 (.06)	.02 (.26)	19,610

α and β are OLS coefficient estimates; their standard errors (estimated with a Newey-West covariance estimator) are in parentheses. N denotes the total sample size.

data sample; the other excludes all observations which overlap EMS realignments.

In all cases, β is estimated to be positive with the EMS data, and significantly greater than zero at conventional significance levels. This result stands in sharp contrast to our estimates derived from floating rates, and is our first chief result. However, the point estimates of β are still significantly below the hypothesized value of unity. Thus, there still appears to be a non-trivial correlation between ϵ and (i-i*), but it varies by exchange rate regime.

Our second main result stems from the fact that β falls by an economically and statistically significant amount when realignments are excluded from the sample. Inducing such sample selection leads β to fall by around .35, a rough estimate of the peso problem bias.

We have checked for the robustness of our two results with respect to a number of perturbations of our basic methodology. For instance, we checked to see if our results depend on the inclusion of country- or year-specific intercept "fixed effect" terms. We have also excluded the later ERM entrants, and, separately, all observations after 1989. Finally, we have estimated β on a country-by-country basis. Our chief results (significantly positive β estimates for fixed exchange rate data, which fall significantly if realignment observations are excluded) are essentially robust to such changes.

IV: Conclusion

It is well known that countries with floating exchange rates and high interest rates tend to experience appreciations. This deviation from uncovered interest parity, known as the "forward discount puzzle" does not appear to characterize our fixed exchange rate data set. In particular, high interest rates are associated with subsequent (though not proportionate) currency *depreciation* in the EMS. Using the same data, we have also found that excluding periods of realignment from a regression of exchange rate changes on interest differentials, leads to a change in the slope coefficient of about -.35. We take the latter to be an estimate of the much discussed "peso problem" bias.

There remain significant deviations from uncovered interest parity, although these are much smaller in the EMS regime of fixed exchange rates than in floating rate regimes. We hope that the contrasting results across exchange rate regimes may enable others to pin down some of the remaining deviations from UIP, especially given our quantification of the peso-problem bias. Explanations of the forward discount bias which emphasize heterogeneous beliefs and trading strategies on foreign exchange markets (either by central banks or by traders who are not fully rational) which are *regime-dependent* seem particularly plausible to us.1/

1/ McCallum (1994) has made some progress along these lines.

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