Department of Economics
and
Institute for Policy Analysis
University of Toronto
150 St. George Street
Toronto, Ontario M5S 1A1
Canada

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by

John E. Floyd

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Author's e-mail: floyd@epas.utoronto.ca
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ABSTRACT

This paper reexamines the uncovered interest parity condition within the context of a structural view of real exchange rate determination that emphasizes the real exchange rate as the relative price of domestic in terms of foreign output. This structural interpretation complements rather than replaces the asset-market view of nominal exchange rate determination. Because structural shocks to the real exchange rate are unpredictable, forward discounts need not predict actual future nominal exchange rate movements with any reliability, except in cases where there are continuing long-term differences in countries' inflation rates. Once the integrated nature of the world capital market is taken into account, it turns out that governments can and probably do smooth price levels, nominal exchange rates and possibly also domestic/foreign interest rate differentials, but have no power to manipulate any of these variables independently of the others. As a result, they cannot bring about major movements in real exchange rates without destabilizing the economy.

Uncovered Interest Parity: A Further Reconsideration

John E. Floyd
University of Toronto*

In a recent contribution to the *Journal of Monetary Economics*, Bennett McCallum presents a thorough analysis of the puzzles that have been uncovered during the last two decades regarding the functioning of the forward and spot foreign exchange markets.[1] He outlines three competing explanations of these puzzles: a) uncovered interest parity does not hold; b) expectations are not rational; and c) the authorities conduct monetary policy by manipulating the nominal exchange rate and domestic/foreign interest rate differential. This paper suggests an alternative way of looking at the forces determining spot and forward exchange rates that reconciles the seeming paradoxes noted in the literature in a simple way without abandoning uncovered interest arbitrage or rational expectations, broadly defined, or making specific assumptions about the smoothing effects of government policy.

The approach developed here takes a structural view of real exchange rate determination that emphasizes the real exchange rate as the relative price of domestic in terms of foreign output. This structural interpretation complements rather than replaces the asset-market view of nominal exchange rate determination that has dominated the literature since the mid 1970s. Exchange rate movements appear, in large part, as shifts in the international relative price structure. Once we recognize that these structural changes are as unpredictable to agents as they are to economists, it becomes unreasonable to expect forward discounts to predict actual future nominal exchange rate movements with any reliability, except in cases where there are continuing long-term differences in countries' inflation rates. Once we also take account of the integrated nature of the world capital market, it turns out that while governments can and probably do smooth price levels, nominal exchange rates and possibly also domestic/foreign interest rate differentials, they have no power to manipulate any of these variables independently of the others. Hence, they cannot bring about fundamental movements in real exchange rates without destabilizing the economy. I first review briefly the facts that have to be explained.[2]

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[1] Bennett T. McCallum, "A Reconsideration of the Uncovered Interest Parity Relationship," *Journal of Monetary Economics*, 33 1994, 105–132.

[2] It should be emphasized that this paper fully supports the implications of the asset theory

The Facts

- Exchange rates are near-random-walks—the null-hypothesis of no unit root can usually be rejected using low power tests but there is evidence of mean reversion for long sample periods.
- The weight of the evidence on predicting exchange rates is that, for practical purposes, the best forecast of tomorrow's exchange rate is today's rate adjusted for ongoing inflation.
- Spot and forward exchange rates move so closely together that, as McCallum notes, the series cannot be clearly distinguished from each other on a dot-matrix printout.
- The forward discount, defined as the log of the forward exchange rate minus the log of the spot rate, is typically a stationary but somewhat persistent variable—not white noise.
- Covered interest parity, defined as

$$i_t - i_t^* = f_t - s_t \tag{1}$$

  where i_t and i_t^* are the domestic and foreign interest rates, and f_t and s_t are the logarithms of the forward and spot exchange rates, defined as the domestic currency prices of foreign currency, holds to an acceptable approximation for most analysis.
- Forward exchange rates are not unbiased predictors of future spot exchange rates, a result that is frequently attributed to either market inefficiency or the existence of time-varying forward exchange risk premia.
- Different econometric estimates are obtained from two alternative formulations of the above unbiasedness proposition that are identical when $\beta = 1.0$:

$$s_{t+1} = \alpha + \beta f_t + \epsilon_{t+1} \tag{2}$$

$$s_{t+1} - s_t = \alpha + \beta(f_t - s_t) + \epsilon_{t+1}. \tag{3}$$

  The first equation can be defined as the 'forward rate' version of the unbiasedness hypothesis and the second as the 'forward discount' version. Econometric estimates of (2) tend

of the exchange rate as developed, for example, in a 1979 paper by Michael Mussa ("Empirical Regularities in the Behavior of Exchange Rates and Theories of the Foreign Exchange Market," in Karl Brunner and Allan H. Meltzer, eds., *Carnegie-Rochester Conference Series on Public Policy*, Vol. 11, *(Policies for Employment, Prices, and Exchange Rates)*, North Holland). Mussa also saw the importance of structural real exchange rates changes but did not pursue their implications. Apart from the bias of forward rate predictions of spot rates that has become evident from analysis of later data, the facts outlined below are essentially those "empirical regularities" he noted.

to yield values for β in the neighborhood of unity as the unbiasedness hypothesis would predict, while estimates of (3) for the post-Bretton Woods period yield estimates for β that are most often below unity—in the data used by McCallum these estimates are in the neighborhood of -3.0 to -5.0.

- The variability of $s_{t+1} - s_t$ is very large relative to the variability of $f_t - s_t$ —about fifteen times as large in the data set examined by McCallum.

Real Exchange Rates as Relative Output Prices

Figure 1 (see page 20) plots the real exchange rates of Germany, the U.K. and Japan viz. the United States, along with the ratios of the price levels in the three countries to the U.S. price level. The real exchange rate is defined as the ratio of the domestic consumer price index to the U.S. consumer price index after the latter has been multiplied by the domestic currency price of the U.S. dollar; the consumer price indexes alone are used in calculating the ratios of price levels. The real exchange rate series show swings of several years duration, downward in the early 1980s, upward after 1984 and, in the cases of Germany and Japan, downward again after 1987. The price level ratios show a rather smooth fall in the price levels of Germany and Japan *relative to* the price level in the United States and a rather smooth rise in the U.K. price level *relative to* the U.S. price level.[3]

During the past two decades traditional foreign exchange market analysis has viewed the exchange rate as an asset price. Deviations of the real exchange rate from some constant 'purchasing power parity' level were thus seen as consequences of the evolution of asset prices in the face of policy shocks and other 'news' affecting asset returns.[4] If we view the real exchange rate as the relative price of domestic in terms of foreign output, however, a natural way to interpret real exchange rate movements is as relative price adjustments. In a world where countries differ in their natural resource endowments and technological change is ongoing, and where labor is not internationally mobile, one would be surprised if purchasing power parity held. Constancy of the real exchange rate through time would be no more plausible

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[3] The use of implicit GNP deflators instead of consumer price indexes yields the same general results.

[4] Robert J. Hodrick, *The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets*, Harwood Academic Publishers, 1987, makes a comprehensive presentation of the issues. See also the paper by Mussa referenced in Footnote 2, Richard Meese and Kenneth Rogoff, "Empirical Exchange Rate Models of the Seventies: Do They Fit Out-of-Sample?", *Journal of International Economics*, 1983, 3–24, and Richard M. Levich, "Empirical Studies of Exchange Rates: Price Behavior, Rate Determination and Market Efficiency," in R. W. Jones and P. B. Kenen, eds., *Handbook of International Economics*, Vol. II, Amsterdam: North Holland, 1985.

than constancy of the price of wheat, automobiles, or TV sets. And the first place one would look to explain real exchange rate movements would be at the factors affecting international equilibrium relative prices.

These factors determining real exchange rate movements can be incorporated in a standard general equilibrium model of domestic and foreign production and consumption of traded and non-traded goods. The derivations are technically straight-forward but extremely messy and not very informative beyond what can be seen on the basis of intuition alone. The problem is that we end up with a reduced form and cannot unravel the underlying structural parameters without a much better understanding of how to define and model technological change than is now possible.[5] For example, observed domestic and foreign real income movements may be either positively or negatively related to movements of the real exchange rate because increases in income typically arise from increases in production of non-traded (home) and traded (home and foreign) goods and have at the same time income effects on the demands for these goods. The effect on the relative price of home in terms of foreign output will depend on whether the growth of technology favors traded vs. non-traded goods on the supply side and on the magnitudes of the income effects on the demands for the two types of goods. Shifts of aggregate demand from the private to the public sector might be expected to shift demand to domestically produced goods from foreign produced goods and thereby raise the real exchange rate. Oil, agricultural, and metals prices influence the terms of trade and thereby directly affect the price of domestic output in terms of foreign output. At the same time, these changes in the international valuation of domestic output affect the distribution of world income and the demand for traded and non-traded goods both at home and abroad. This, combined with the fact that the terms of trade are necessarily related

[5] A substantial literature has developed on these and related issues beginning with Bela Balassa, "The Purchasing Power Parity Doctrine: A Reappraisal," *Journal of Political Economy*, Vol. 72, December 1964, 584–96, Paul A. Samuelson, "Theoretical Notes on Trade Problems," *Review of Economics and Statistics*, Vol. 46, May 1964, 145–54, and later, Lawrence H. Officer, *Purchasing Power Parity and Exchange Rates: Theory, Evidence and Relevance*, London and Greenwich Connecticut: JAI Press, 1982. More recently, the emphasis has been on representative agent models—see Allan C. Stockman, "A Theory of Exchange Rate Determination," *Journal of Political Economy*, Vol. 88, No. 4 (August), 1980, and "Real Exchange Rates Under Alternative Exchange Rate Regimes," *Journal of International Money and Finance*, No. 2, 1983, 147–66, Allan C. Stockman and Lars E. O. Svensson, "Capital Flows, Investment and Exchange Rates," *Journal of Monetary Economics*, Vol. 19, 1987, 171–202, Elhanan Helpman, "An Exploration in the Theory of Exchange Rate Regimes," *Journal of Political Economy*, Vol. 89, No. 5 (October), 1981, 865–890, Elhanan Helpman and Assaf Razin, "Dynamics of a Floating Exchange Rate Regime," *Journal of Political Economy*, Vol. 90, No. 4 (August), 1982, and Sebastian Edwards, *Real Exchange Rates, Devaluation, and Adjustment*, MIT Press, 1989.

to supply-side forces affecting the relative prices of non-traded in terms of traded goods in either or both the domestic and foreign economies, produces important indirect relationships between commodity prices and the real exchange rate.

Although political forces and resulting government policy actions will frequently play a direct role, probably the most important driving force here is world technology, which is impossible to model. As the world economy grows some natural resources are likely to be better candidates for development than others, and capital will flow to the regions in which these favored resources are present. This will cause the real exchange rates in these regions to rise to effect the inward transfer of real capital. At the same time, the differential impact of world cyclical and other transitory factors across areas is likely to induce consumption smoothing, which will temporarily raise the real exchange rates of borrowing regions. These may or may not be the regions that are receiving longer term injections of rest-of-world savings for purposes of resource development. Finally, countries' permanent savings rates may change, as appears to have happened in the U.S. over the past decade.[6]

It is not surprising that these real forces should lead to real exchange rate series best described as near-random-walk processes. In any period the 'hit' to the real exchange rate resulting from on-going technological change and the response of the world economy to it, as well as political developments affecting local savings and investment opportunities, would seem just as likely to be in one direction as in the other. This will result in real exchange rate series that wander widely from any initial value. At the same time, it would seem improbable that any country or region should have more than its share of the bad (good?) luck over a long period of, say, 100 years. An area's resource endowment will perhaps be favored by world technology for a span of years but then new resources that the region does not possess will become the focus of development. Political instability may reduce investment opportunities and savings rates for a time but then things will eventually change as conflicts are resolved, migration occurs and national borders are redrawn. Virtually zero trends of countries' real exchange rates over many decades, and the long-term mean reversion that this implies, should not be a surprise. There are, of course, technological, political and other factors that explain all movements in real exchange rates, but we do not have the capacity to model and forecast them. So real exchange rates appear to us as random walks with mean reversion in the very long run.

Market participants have the same information as economists. To forecast real exchange

[6] Gross private plus government savings hovered around 16.3% of GNP between 1950 and 1977, jumped to 18% during 1978–81, and then declined steadily to 15.6% in 1982–85, 13.9% in 1986–89 and 12.5% in 1990–93 (Source: Citibase).

rate movements one has to know the parameters of the international relative price structure and predict how the forcing variables will evolve in the future—an impossible task given the current state of knowledge. Accordingly, it is not surprising that the best predictor of tomorrow's real exchange rate is likely to be today's. Some individual agents will act on opinion and take speculative positions—sometimes gaining and other times losing—but no scientific verification of *ex ante* predictive success will be possible.

Implications for the Forward Discount

This random-walk behavior of the real exchange rate has important implications for determining the forward discount. To explore these it is useful to abstract for the moment from differences between the domestic and foreign inflation rates.

Equal Domestic and Foreign Inflation Rates

Suppose that the real exchange rate is a random-walk process, domestic and foreign inflation rates are the same and these facts are known by all agents. Two possible scenarios arise according to whether agents have (or think they have) information about the innovations in this random walk process. If agents knowingly have no information then the forward exchange rate will equal the current spot rate and the β coefficient in equation (3) will be undefined. The β-coefficient in (2) will be unity.

The alternative scenario is that agents believe that they have information about the innovations in the process determining the real exchange rate. If they have perfect information, they will forecast the real exchange rate accurately each period and the β-coefficients in both (2) and (3) will be unity. If they act on information they think they have, but that information is worthless, the β-coefficient in (3) will be zero since the random variation in $(f_t - s_t)$ will be uncorrelated with the variation in $(s_{t+1} - s_t)$. At the same time, the 'forward rate' representation (2) will yield an estimate of β insignificantly different from unity as long as the forward rate tracks the spot rate well through time. This will be the case when the variance of the forward discount is small in relation to the variance of the innovations to the spot rate. Suppose that, on average, agents correctly predict some fraction of the innovations in the real exchange rate rate. Then there will be a positive correlation between $(f_t - s_t)$ and $(s_{t+1} - s_t)$ in (3) and a positive estimated value for β. It turns out that β will equal the ratio of the variance of the correctly predicted component of the real exchange rate innovations to the variance of the forward discount.[7] If agents act only on 'hard news' and are nearly always

[7] This is a standard errors-in-variables interpretation of (3) where the error in predicting the innovation in the inflation rate is interpreted as a measurement error. See, for example, G. S. Maddala, *Introduction to Econometrics*, New York: MacMillan, 1988, pp. 380–382.

right, β will approach unity; if they act on 'soft news' and, say, 10% of the variance of their forward discount settings is actually reflected in changes in the spot rate between this period and next, β will equal 0.10. The short-fall of β from unity is thus a measure of the quality of the news that is acted upon.

But this ignores the possibility that agents may learn from their own forecast errors. If agents can fit equation (3) to their own forecasts and calculate the resulting "β's", they can scale their forecasts so that, on average, they will not overpredict future movements in the spot rate. The estimated β's for the scaled forecasts will then be unity and equations (2) and (3) describing the behavior of agents in the aggregate will then both yield unitary estimates of β.

There are two reasons why the aggregate forecasts may not be optimal in the sense described above. First, some agents may take speculative positions only infrequently, on occasions when they "think" they have good information. These agents may not have a sufficiently long forecast history to estimate their β-coefficients. Second, the forecast error process may not be the same at all points in time. Since different technological and other forces affect real exchange rates at different times, the errors agents make in predicting future exchange rate movements on the basis of the available "information" may be different during some periods than others in ways that they have an insufficiently long forecast history to estimate. In a changing world, past forecast errors will not necessarily be a good predictor of future forecast errors. The estimated β in equation (3) will thus represent an historic average prediction error that will give little guidance in making current forecasts. When agents behave rationally, the estimated β will incorporate whatever optimization they are able to effect.

Suppose that the major influence in the forward market is agents who adopt naive forecasts but that activist activity is nevertheless present on the part of a significant fringe of agents who from time to time think they have information worth acting on. Suppose further that, despite occasional mammoth profits by some individuals in this group, the forecasts of these activist agents are, on average, worthless. The random noise in the observed forward discount will generate a defined estimate of β in equation (3)—that estimate will be zero. The differences between the spot and forward exchange rates resulting from the activities of this second group of agents must be small in relation to the transactions costs facing the naive-forecasting agents—otherwise, the latter agents will profit from the ineptness of the former.

The Role of Inflation Rate Differences

The role of the domestic and foreign expected inflation rates must now be incorporated. From the definition of the real exchange rate we have

$$s_{t+1} - s_t = (p_{t+1} - p_t) - (p^*_{t+1} - p^*_t) - (q_{t+1} - q_t) \tag{4}$$

where p_t and p^*_t are the logarithms of the domestic and foreign price levels and q_t is the logarithm of the real exchange rate. Under the assumption that the real exchange rate is a random walk, $E_t q_{t+1} - q_t$ will be zero and the forward discount will equal

$$f_t - s_t = E_t s_{t+1} - s_t = (E_t p_{t+1} - p_t) - (E_t p^*_{t+1} - p^*_t), \tag{5}$$

the difference between the expected rates of domestic and foreign inflation between the periods t and $t+1$.

Casual knowledge about the stability of inflation rates might suggest that a simple projection of the current domestic/foreign inflation rate difference will provide an adequate inflation-component to the one-month forward discount—after all, it is well-known that the Canadian inflation rate, for example, is roughly zero and the U.S. inflation rate around three percent. This is not the case. Suppose that the Canadian inflation rate for the next month is -0.11 percent—a seemingly trivial deviation from zero—and the U.S. inflation rate is 3.3 percent, less than a third of a percentage point above its projected level. The month over month Canada/U.S inflation rate difference is -0.41 percent, which amounts to nearly 5 percentage points on an annual basis! Being able to take into account such seemingly small month-to-month inflation rate differences could yield substantial financial advantage, and attempts to take them into account could result in substantial deviations of forward exchange rates relative to current spot rates.

The one-month forward discounts on the Deutschmark, Pound and Yen together with the previous month's CPI inflation rate differentials in the respective countries vs. the U.S. are given in Figure 2 (see page 21) . The month-to-month inflation rate differentials show very substantial variability both in absolute terms and relative to the forward discounts on the respective currencies. In Figure 3 (see page 22) the month-to-month inflation rate is replaced with the year-over-year inflation rate. Even when much of the noise is removed from the inflation rate series, the differences between those series and the corresponding forward discounts are substantial. If agents were using naive exchange rate forecasts they seriously underpredicted the German, British, and Japanese inflation rates relative to the U.S. inflation rates in the 1980-84 period and overpredicted the U.K./U.S. inflation rate differential during the period 1984-87. Of course, these differences could also reflect risk premia.

It is more difficult for agents to adopt a naive forecasting rule for the future inflation rate differential than for the future *level* of the real exchange rate because variability of the innovations relative to current values is much greater for the former series than for the latter.

Nevertheless, it is clear from Table 1 (see page 23) and the behavior of the forward discount series in figures 2 (see page 21) and 3 (see page 22) that agents took average inflation rate differences into account in setting forward rates. The first row of Table 1 (see page 23) indicates that inflation rates in Germany and Japan were more than three percentage points lower on average over the period from January 1978 to July 1990 than in the United States while the U.K. inflation rate averaged about two percentage points above. As shown in the second row, these differences in inflation rates are reflected in corresponding negative forward discounts, on average, on the Deutschmark and Yen in terms of the dollar and in a positive forward discount on the Pound. The levels of the forward discount series in figures 2 (see page 21) and 3 (see page 22) also bear this out. There are also significant positive relationships between changes in both month-over-month and year-over-year inflation rate differences and the forward discounts on these currencies, although the fraction of the variance of the forward discount explained is small, as might be expected. This is shown in the regression results presented in Table 2 (see page 24) and is evident as well in the plots of the series in Figure 3 (see page 22) .

The above evidence suggests that agents set the inflation component of the forward discount on the basis of past history with an adjustment based on "news". Since current "facts" are subject to differing interpretations, random variability of the forward discount is inevitable. Even if every agent, realizing the insurmountable problems in forecasting real exchange rates, naively projects last period's real exchange rate forward, there will be variability in the forward discount arising from variation in forecasts of the inflation differential not reflected in future innovations in the spot exchange rate. Widespread belief in the random-walk nature of real exchange rates together with unpredictability of real exchange rate innovations will therefore result in estimated β-coefficients in equation (3) well below unity and quite possibly in the neighborhood of zero. The very low variability of forward discounts relative to the month-to-month innovations in nominal exchange rates indicated in rows (5), (7) and (8) of Table 1 (see page 23) and in Figure 4 (see page 25) confirms that the spot rate tracks the forward rate closely through time, suggesting that the estimated β-coefficients in equation (2) should not be far from unity.[8]

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[8] The sharp positive spikes in the forward discounts of all currencies in 1980 followed in 1981 by sharp declines in the cases of the Pound and the Yen and by sharp fluctuations in the case of the Deutschmark may indicate changing opinions about future inflation-rate differentials following on the Fed's contractionary monetary policy and the subsequent decline in world inflation rates. An alternative interpretation of the instability of the forward discounts in 1980 and 1981 might focus on the possibility that agents engaged in activist speculative response to predicted movements in real exchange rates.

Nothing in the above analysis suggests that markets are inefficient in the sense that agents do not use all the information available to them. The problem is rather that the information is imperfect and subject to differing interpretations and that agents' reactions in response to these interpretations depend upon their attitudes toward risk.

Overshooting Effects of Monetary Shocks

The simple formulation above nicely explains all the seemingly anomalous facts noted at the beginning of this paper but one—it does not explain why negative estimates of β are obtained so frequently in empirical work. Barring econometric estimation biases of a purely technical sort that investigators have not yet uncovered, one place to look for an explanation is, as McCallum notes, at possible effects of a government policy induced relationship between the forward discount and next period's change in the spot exchange rate. Before doing so, we must look more closely at the question of exchange rate overshooting.

In a world where assets can be freely exchanged across international boundaries, two conditions must hold for agents' portfolios to be in equilibrium:

$$m_t - h_t = p_t + y_t - \phi\, r_t - \phi\, (E_t p_{t+1} - p_t) \tag{6}$$

$$r_t = r_t^* + \rho - (E_t q_{t+1} - q_t) \tag{7}$$

where m_t and y_t are the logarithms of the domestic nominal money supply and real income, r_t and r_t^* are the domestic and foreign real interest rates, h_t is a logarithmic demand for money shift variable, ρ is a risk premium, and ϕ is the (positively defined) interest semi-elasticity of demand for money. For convenience, the income elasticity of demand for money is assumed equal to unity. Equation (6) is the standard demand function for money and (7) is the Euler condition that the risk-adjusted returns from holding domestic and foreign assets must be the same. Substitution of (7) into (6) yields

$$p_t + \phi\, (E_t q_{t+1} - q_t) - \phi\, (E_t p_{t+1} - p_t) = m_t - h_t - y_t + \phi\, (r_t^* + \rho) = z_t \tag{8}$$

where the exogenous variables are moved to the right side of the equality and aggregated into the variable z_t.

The price level of domestic output can be expressed as

$$p_t = \alpha\, \hat{p}_t + (1 - \alpha)\, s_t \tag{9}$$

where $\hat{p}_t$ is the domestic currency price of non-traded goods and α is the share of non-traded goods in the domestic price index. Taking the situation in the rest of the world as exogenous, the price of traded goods can be treated as proportional to the nominal exchange rate.[9]

Suppose now that there is a one-shot positive shift in the exogenous right-hand-side variables—Δz_t—that is fully anticipated by all agents. As long as there is no change in agents' expectations about the future inflation rate or the future innovations in the real exchange rate, the result will be an immediate and equal increase in p_t. From our definition of the real exchange rate

$$q_t = p_t - p_t^* - s_t \tag{10}$$

this will also imply an immediate equal increase in s_t.

Alternatively, suppose that the one-shot shift in z_t is not anticipated by private agents and that all current period price-setting commitments are in place when it occurs, implying that $\hat{p}_t$ cannot rise. Agents will be holding excess money balances. Portfolio equilibrium will require an exchange of these excess money holdings for foreign-held non-monetary assets, leading to an incipient net capital outflow. The resulting excess demand for foreign exchange will lead to a depreciation of the domestic currency to the point where the equilibrium condition (8) holds. Assume that agents continue to view the current period's real exchange rate as the best predictor of the real exchange rate that will occur next period and make the same adjustment for the expected domestic/foreign inflation differential as they did previously. The domestic/foreign interest rate differential will then be unaffected and p_t will rise by an amount equal to Δz_t. Since $\hat{p}_t$ does not change, this will imply an increase in s_t equal to $1/(1-\alpha)\Delta z_t$.

Next period, agents will be able to adjust $\hat{p}_t$. Since q_{t+1} is by assumption unaffected, s_{t+1} will fall back to the level it would have attained in the previous period had the monetary shock been fully anticipated—that is, p, $\hat{p}$ and s will all be higher in period $t+1$ by the amount Δz_t. When the money shock is unanticipated, the current period nominal exchange rate adjustment will overshoot the long-run equilibrium adjustment.

There is an important difference between the model developed here and standard Dornbusch overshooting models.[10] The latter models postulate that agents know in the current period that the exchange rate is overshooting its long run equilibrium. As a result, an overshooting depreciation will be accompanied by an expected appreciation next period and the forward discount on the domestic currency and relative domestic nominal interest rates will

[9] As long as the fraction of total absorption falling on non-traded goods does not differ much from the share of non-traded goods in total production, it will make little difference whether p_t is an index of output prices such as the GDP deflator or an index of prices of goods absorbed such as the CPI.

[10] Rudiger Dornbusch, "The Theory of Flexible Exchange Rate Regimes and Macroeconomic Policy", *The Scandinavian Journal of Economics*, Vol. 78, 1976.

fall. This will increase the quantity of money demanded and moderate the overshooting nominal and real exchange rate adjustments. If, however, agents form their expectations under the assumption that the real exchange rate is a random walk process in which the innovations are not observed ahead of time, they will have no way of determining whether a particular exchange rate adjustment is an overshooting one and a response of interest rate differentials and the forward discount to overshooting exchange rate adjustments will not be present.

Leaning Against the Wind

It has already been shown that the more accurate are agents' predictions as to the change in the spot exchange rate between the current and the next period, the closer estimated β in equation (3) will be to unity. Negative values for β indicate that agents' predictions are not merely inaccurate, but are dominated by agents that get the sign wrong. Could attempts by the authorities to smooth the exchange rate be responsible for this, as McCallum's third explanation suggests?

The authorities can prevent overshooting movements in the exchange rate by adopting an *orderly markets* monetary policy in which they constantly adjust m_t in order to stabilize z_t. This requires that they be able to determine when portfolio shocks arising from domestic excess demands and supplies of money are driving the exchange rate. This turns out to be the same as recognizing when monetary conditions are tighter or easier in the domestic economy than abroad—tighter conditions abroad, for example, will raise world interest rates and reduce the quantity of money demanded at home, requiring that the authorities reduce the money supply accordingly if overshooting exchange rate adjustments are to be avoided. Beyond this the policy options facing the authorities are severely constrained. The nature of this constraint depends on how agents make forecasts. There are two scenarios, both of which assume that the real exchange rate is generated by a random walk or near random walk process and the expected future inflation rate is conditioned primarily by past history.

The first scenario has agents forming expectations from naive random walk forecasts—next period's real exchange rate is expected to equal this period's and the inflation rate from this period to next is expected to differ in only minor ways from the inflation rate that was expected last period. The domestic/foreign interest rate differential will change very little from the previous period. Random monetary shocks, Δz_t, that are not anticipated beforehand by agents will occur no matter how expectations are formed. If the authorities hold m_t constant, the equilibrium price level will change period to period in response to these shocks by the amount Δz_t—these price changes will be concentrated entirely in the traded goods sector and brought about by overshooting adjustments of the nominal exchange rate. Period to period movements of the nominal exchange rate will thus depend upon the overshooting response to these monetary shocks together with the stochastic shocks to the real exchange rate. The authorities can stabilize the price level by an orderly markets monetary policy that adjusts m_t so as to eliminate the shocks to z_t. They can stabilize the nominal exchange rate by adopting either a fixed exchange rate rule that shifts all real exchange rate shocks onto the price level, or a form of managed floating that passes through onto the price level only some portion of the real exchange rate shocks—in both cases, stabilizing the nominal exchange rate involves destabilizing the price level. The authorities cannot stabilize the real exchange rate because they cannot influence either the real factors affecting it or agents' expectations about future changes in it. Under the expectations assumptions being considered, none of these smoothing policies will affect the domestic/foreign interest rate differential.

In the second scenario, agents recognize the underlying processes by which the exchange rate and inflation rate evolve, but now perceive that they can peek at the innovations in the real exchange rate and inflation rate that will occur between this period and next. This will cause them to attach greater probability to movements of the real exchange rate and inflation rate—and hence, the nominal exchange rate—in one direction as opposed to the other. The forward discount and the domestic/foreign interest rate differential will now reflect these anticipated movements in the nominal exchange rate. In addition to the random unanticipated shocks to z_t that would occur in any event there will now be shocks to the quantity of money demanded that reflect these changes in the interest rate differential. All of these shocks to the excess demand for money can be neutralized by policy induced shocks to the supply of money of the proper direction and magnitude. In the absence of such smoothing there will be overshooting adjustments to the nominal exchange rate and to the price level. Again, the authorities can shift real exchange rate shocks onto the price level by stabilizing the nominal exchange rate. Once agents are assumed to abandon a naive random walk forecasting rule, the possibility arises that they might be able to recognize when overshooting exchange rate adjustments are occurring and adjust the forward discount and domestic/foreign interest rate differential accordingly. As in the other scenario, the authorities can temporarily manipulate real exchange rates by deliberately causing overshooting adjustments in the nominal exchange rate and price level. In addition, to the extent that agents have (or think they have) some information about movements in the long-run equilibrium real exchange rate, the authorities may be able to manipulate the domestic/foreign interest rate differential, though at the cost of destabilizing both the domestic price level and the nominal exchange rate.

Under both these scenarios, negative values of the estimated β coefficient in equation (3) will result only if agents consistently make wrong predictions about the direction of change of the spot rate between this period and next.

The substantial differences between the policy stabilization opportunities here and those in McCallum's paper and the vast literature from which it derives must be made clear. In the present analysis there is no way in which the authorities can manipulate the domestic/foreign interest rate differential and the nominal exchange rate independently of each other. The presence of equation (7) makes it impossible for the authorities to change the domestic nominal interest rate without changing either the risk premium ρ or the expected rate of change in the nominal exchange rate. It might be possible, depending on how agents form expectations, to impose an expected rate of change in the nominal exchange rate by creating overshooting, but this will imply a loss of control over both the exchange rate and the price level. A particular the exchange rate could be imposed in the current period by appropriately setting m_t but the authorities then would have to relinquish control over the price level as well as any control they might have over the domestic/foreign nominal interest rate differential. If the risk premium depends on the covariance structure of asset returns in the economy, as the modern theory of finance would have us believe, one would be surprised to find it responsive to current period shocks to the nominal money supply independently of some money supply generating process—a current money supply shock would have to lead agents to change their view of the covariance structure of asset returns. It might be argued that the authorities can manipulate certain short-term "overnight" interest rates independently of other variables in the economy for short periods. This would be possible if the authorities are high volume players in the market and private agents take time to reevaluate their portfolios in response to the authorities' actions. But this does not break the interdependence of the exchange rate, the price level, and the domestic/foreign interest differentials on the bulk of assets with which financial markets are concerned as long as agents can quickly move excess money holdings into other assets.

A second feature of the analysis developed here that leads to different results than found in the literature is the treatment of the real exchange rate as the relative price of domestic in terms of foreign output *as well as* an asset price. This view of the real exchange rate suggests that agents' expectations about future exchange rates will be dominated by a naive projection of current rates while the expectations generation process in the traditional asset theoretic approach implies that, on average, agents' expectations of next period's nominal exchange rate will equal the actual realization. This latter specification is not an unreasonable one in a world where all movements of the real exchange rate around some purchasing power parity level represents asset-market-related disequilibrating shocks that agents should be expected to know something about. But it imposes a heavy load on the unbiasedness hypothesis in reconciling the estimates of β in equations (2) and (3) in a world where real exchange rate innovations are a reflection of on-going changes in the world equilibrium relative price structure together with consumption smoothing in response to world business cycles. Once we take account of the fact that we know very little about the process generating *equilibrium* real exchange rates and recognize that agents may follow economists advice about the forecastability of real exchange rates, a framework more congenial to rational expectations and market efficiency explanations emerges. We now only have to explain why estimates of β in equation (3) tend to be negative and not why they are virtually always less than unity.

Why Then Are Estimates of β Negative?

It remains to explain in a manner consistent with economic rationality why agents seem to be acting on perverse predictions of future nominal exchange rate movements. Because all tests of market efficiency involve simultaneous tests of a particular model of expectations generation, no definitive test is possible. The best we can hope for is to be able to explain this seeming anomalous behavior in a fashion consistent with reasonable costs of obtaining information and plausible attitudes toward risk.

It is fruitful here to follow the line of argument developed by De Long, Shleifer, Summers and Waldman and make a distinction between arbitragers and noise traders.[11] We could thus explain negative observed β-coefficients as the result of market activity dominated by poorly informed agents who gamble on the basis of their assessment of existing information, getting the sign wrong more than half the time but occasionally in individual cases making enormous profits. The question is then why it does not pay more professional and better-informed agents, called arbitragers, to eliminate this perverse relationship between the forward discount and next period's innovation in the spot rate by continually taking forward positions on the basis of naive random-walk forecasts. The distinction between noise traders and arbitragers here is not a rigid one—one could think of a continuum ranging from pure noise traders at one end to pure arbitragers at the other, with the positions of particular traders along the continuum depending upon the quality of information they are able to obtain and willing to act upon and their attitudes toward risk.

The issue is whether it is profitable for arbitragers to eliminate negative β-coefficients that result from noise trading. First it should be noted, as McCallum does, that the explanatory power of the forward discount in predicting the future spot rate is extremely low. The reproduction of his results, shown in Table 3 (see page 26) , yields values for R^2 less than

[11] J. Bradford De Long, Andrei Shleifer, Lawrence H. Summers, and Robert J. Waldman, "The Size and Incidence of Losses from Noise Trading," *Journal of Finance*, 40, July 1989, 681–696, "Noise Trader Risk in Financial Markets," *Journal of Political Economy*, 1990, and "Positive Feedback Investment Strategies and Destabilizing Rational Speculation," *Journal of Finance*, 1990. For a useful summary of these ideas, see Andrei Shleifer and Lawrence H. Summers, "The Noise Trader Approach to Finance," *Journal of Economic Perspectives*, Vol. 4, No. 2 (Spring), 1990, 19–33.

.06 in the case of the Deutschmark and Yen and .11 in the case of the Pound. The scatter diagrams in Figure 5 (see page 27) give, as he notes, the clear impression of weakness rather than strength of any underlying relationship.[12] When we take into account that the average estimated β over 75 published estimates is -.88 (as compared to values of -3 to -5 found here) and positive estimates are sometimes obtained[13] it is apparent that anyone attempting to profit from this evidence of perverse market expectations is mining very low-grade ore under highly variable conditions. This is especially the case since the estimated βs are historic average values—there is little reason to believe that, looking forward at any point in time, we will observe the same forecast error process that we have observed in the past.

Suppose we imagine an investment strategy of calculating each period the future spot rate expected from a naive horizontal projection of the current real exchange rate augmented by the last month's realized year-over-year inflation rate differential, and then selling foreign currencies short if this expected spot rate is below the current forward rate and buying them forward if it is above.[14] The cumulative discounted profit as a percentage of the constant month by month forward commitment each period is shown in Table 4 (see page 28) for the Deutschmark, Pound and Yen for the period 1978:1 to 1990:1. Gains and losses are accumulated and discounted back to Jan. 1, 1978 at the U.S. 90 day commercial paper rate and various transactions cost assumptions are used, ranging from one-tenth to one-half a percentage point on each month's turnaround. Transactions costs can be thought of comprising two different elements—the cost of buying and selling spot and forward currency, and the additional interest rate that one must allow on the securities used as collateral to compensate for the fact that the returns from them are now at greater risk. The table indicates that a clear discounted future profit does not emerge in all three cases at transactions costs of 1% or above, although a substantial profit for the three cases combined does appear when the transactions cost parameter is less than 0.4 percentage points. It would seem reasonable that brokerage fees alone would absorb this amount, to say nothing of the additional risk.[15]

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[12] The relationship between the change in the spot rate and the previous period's interest rate differential is also given in Table 3 (see page 26) . In McCallum's scatter diagrams the forward and spot exchange rates are defined to be the inverse of the definitions adopted here. The regression results in Table 3 (see page 26) also differ slightly from McCallum's because I corrected a minor apparent typographical data error.

[13] See K. A. Froot and R. H. Thaler, "Anomalies: Foreign Exchange," *Journal of Economic Perspectives*, 4 (Fall), 1990, 179–192.

[14] The results that follow do not differ significantly if we use the month-over-month rather than the year-over-year inflation rate differential.

[15] It might be argued that although brokerage fees of a third of a percent are lower than the

The unreasonably low rate used to discount the future gains and losses tends to make those gains and losses larger than they otherwise would be. Taking into account that hindsight is better than foresight and the data in question were generated in particular set of countries for a particular time period under conditions that need not be repeated, I conclude that the observed negative β-coefficients do not seem to suggest arbitrage opportunities that are worth exploiting.

Conclusions

This paper explores the implications for spot and forward exchange market behavior of modelling real exchange rates as the relative prices of countries' outputs, and thereby extends and complements the asset-price view of exchange rate determination that has dominated international finance in recent decades. Three important refinements of the conventional view of the determination of and relationship between forward and future spot rates emerge. First, given what we know of the fundamentals determining real exchange rate movements, it would be surprising if variations in the forward discount were to play a significant role in explaining actual variations in future spot rates. This is in contrast to the more conventional view that, barring time varying risk premia or violations of market efficiency, the forward discount should have a one-to-one relationship, on average, to realized future movements in the spot rate. Once we view fundamental real exchange rate movements as changes in equilibrium levels rather than departures from some equilibrium purchasing power parity level, less stringent demands are placed on the explanatory power of the efficient markets hypothesis. What would be seen as potential departures from market efficiency in the conventional view turn out to be not necessarily the case in this broader framework. Second, all of the 'stylized facts' about spot and forward exchange rate behavior are easily explained under this broader theory without having to resort either to time varying risk premia or to market inefficiencies, defined as deviations of prices from fundamentals of sufficient magnitude to enable expected arbitrage profits in excess of transactions costs after allowing for risk. While weak perverse negative relationships between the forward discount and future movements in the spot exchange rate are found in many empirical studies, indications are that the potential profits from exploiting these are probably below reasonable transactions costs. Finally, once the appropriate integration of domestic capital markets with the world capital market is incorporated into the

typical individual speculator would usually have to pay, large institutions and floor traders can trade on their own account at much smaller costs. This argument, however, fails to take into account the opportunity costs of using resources to exercise one particular trading strategy rather another that might be even more profitable—unless existing trading and accounting resources are underutilized, more will have to be purchased.

analysis, the avenues for using monetary policy to manipulate the domestic interest rates, the exchange rate and the domestic price level are severely constrained. To the extent that agents adopt random walk forecasts of real exchange rates and forecasts of international inflation rate differentials based primarily on historic evidence, the authorities will not be able to affect the domestic/foreign interest rate differential at all, except insofar as they can influence the risk from holding domestic assets. If agents have some information about the forces that will determine the future exchange rate, the authorities will be able to manipulate domestic interest rates, but only at the cost of destabilizing both the exchange rate and the domestic price level. Stabilizing either of these two latter variables will sacrifice stability of the other and, as well, the domestic interest rate. The results suggest clearly that domestic monetary shocks unmatched by equivalent shocks abroad will lead to substantial and immediate movements in nominal and real exchange rates, although the real exchange rate effects will be only temporary. The authorities can use monetary expansion and contraction that is unanticipated by private agents to move the exchange rate in the desired direction. But the magnitude of the movement of the exchange rate in that direction and the effect, if any, that the policy will have on the interest rate differential will depend upon what information agents have (or think they have) about future innovations in the real exchange rate and the relative rates of domestic and foreign inflation. Since this information set will differ from situation to situation and be difficult for the authorities to quantify, the quantitative effects of unanticipated policy shocks will be unpredictable. As a result, monetary policy can destabilize the real exchange rate but not control it an any useful way.

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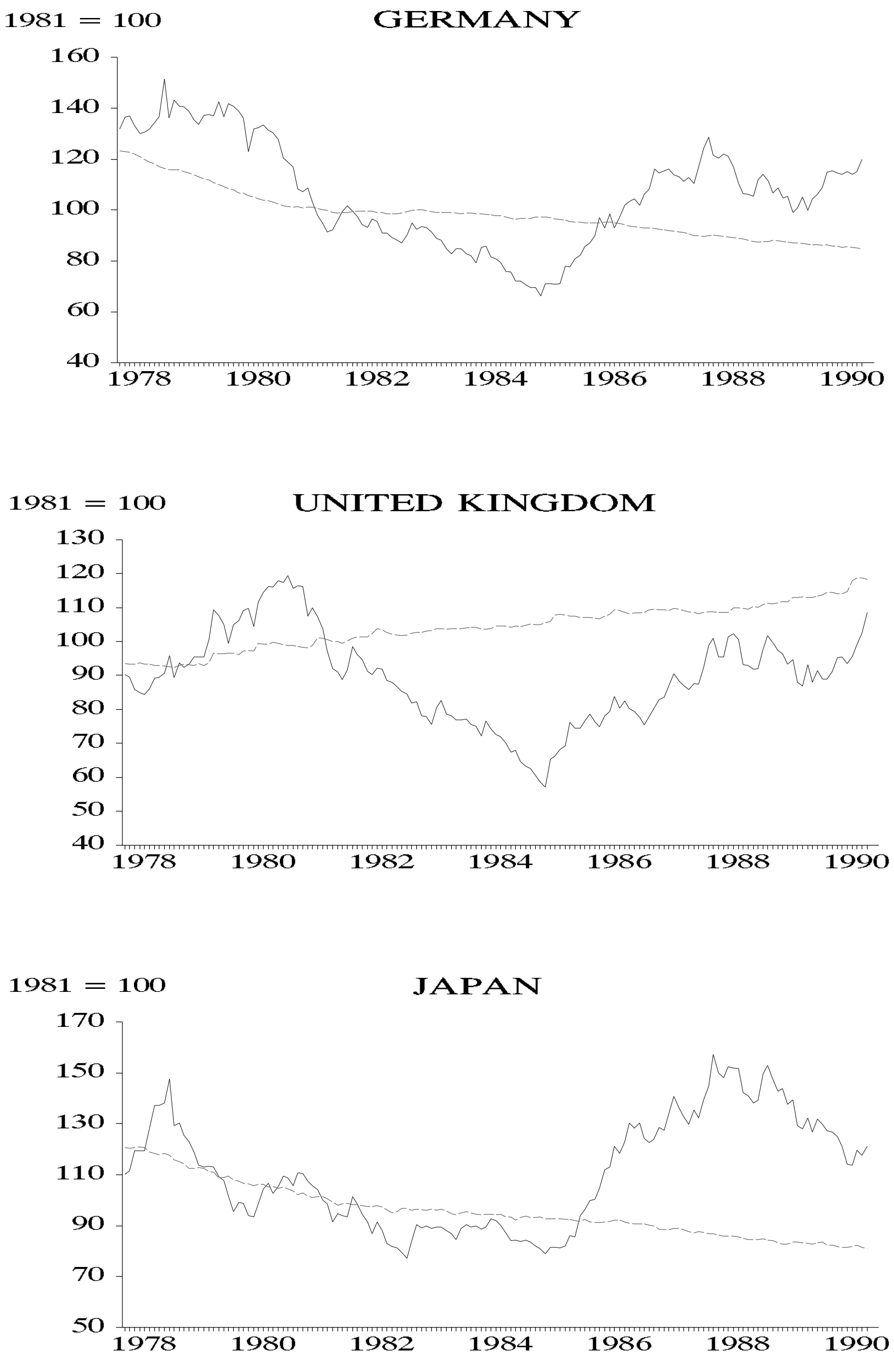

Figure 1: Real exchange rate viz. à viz. the U.S. (*solid line*) and ratio of the domestic price level to the U.S. price level (*dotted line*): Germany, the United Kingdom and Japan, 1978–1990, 1981 = 100. Source: *International Financial Statistics*.

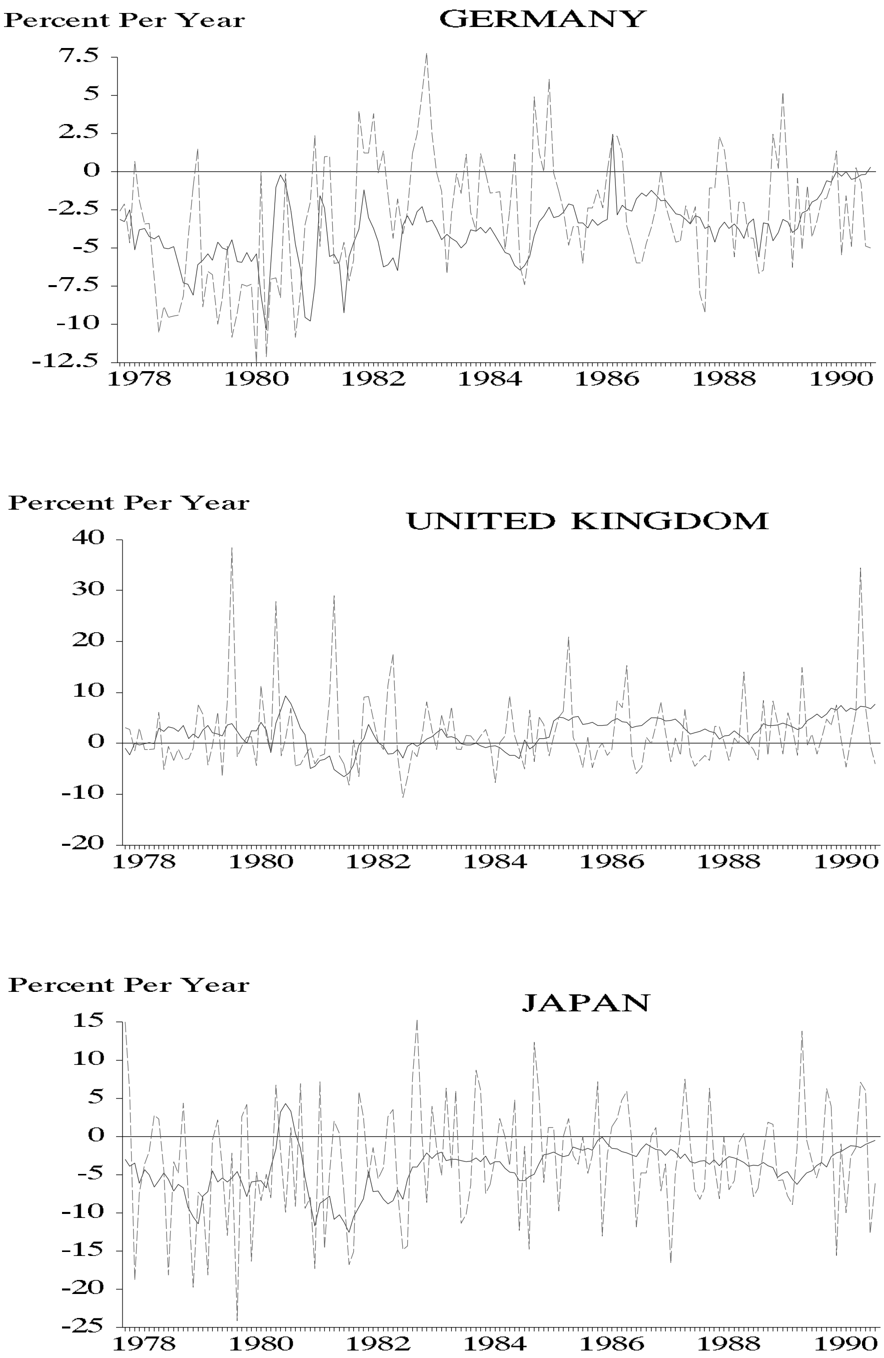

Figure 2: Forward discount of the domestic currency in terms of the U.S. dollar (*solid line*) and the excess of last period's month to month domestic inflation rate over the corresponding U.S. inflation rate (*dotted line*): Germany, the United Kingdom and Japan, 1978–1990, Percent per year. Source: See Table 1.

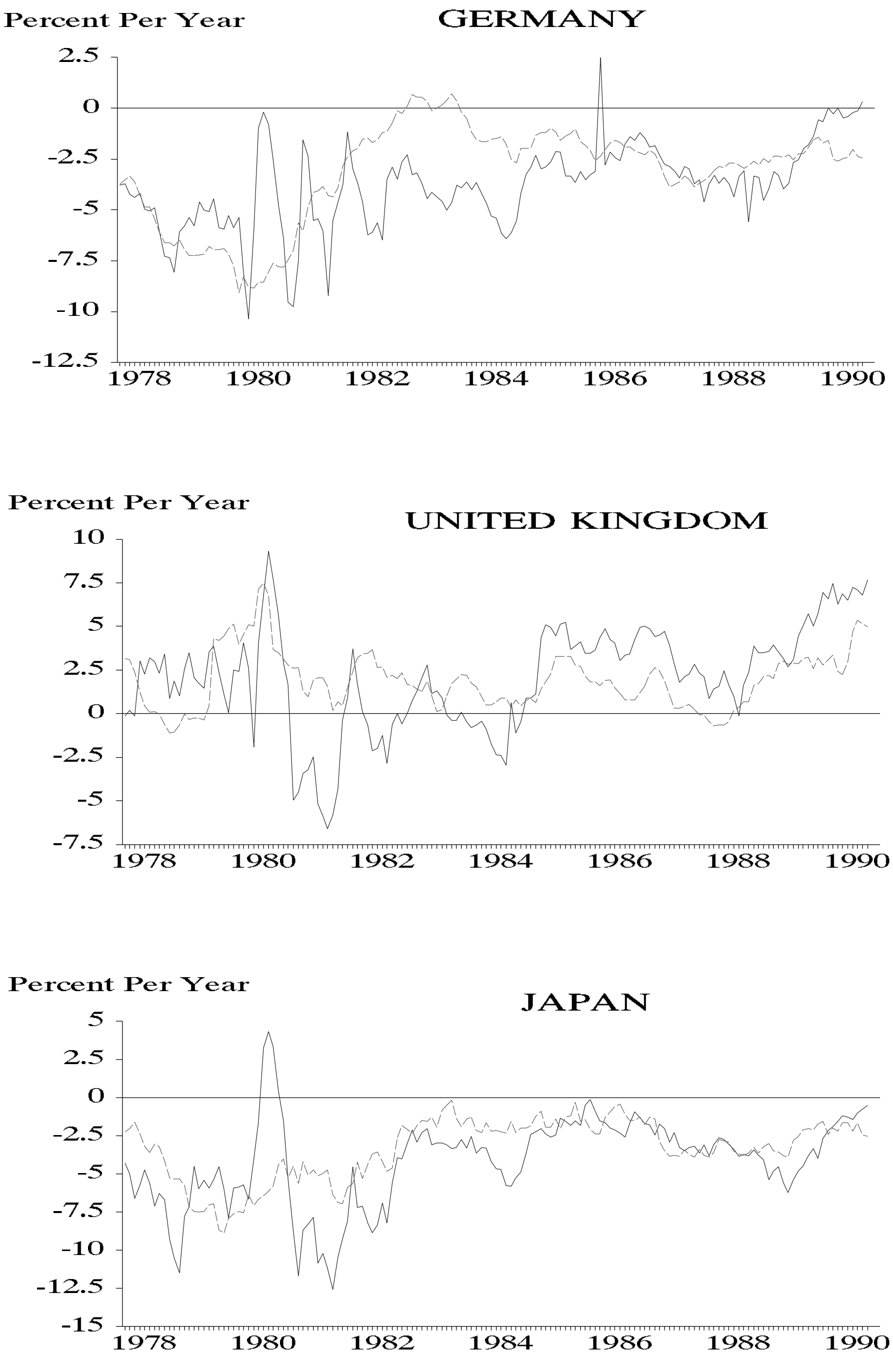

Figure 3: Forward discount of the domestic currency in terms of the U.S. dollar (*solid line*) and the excess of last period's year over year domestic inflation rate over the corresponding U.S. inflation rate (*dotted line*): Germany, the United Kingdom and Japan, 1978–1990, Percent per year. Source: See Table 1.

Table 1: Inflation Rates, Spot Rate Innovations and Forward Discounts: Germany, the U.K. and Japan vs. the U.S., 1878:1–1990:7

	GERMANY	U. K.	JAPAN
(1) Mean of Domestic Minus U.S. Inflation Rate – % per year	-3.18	1.91	-3.37
(2) Mean Forward Discount on the Domestic Currency – % per year	-3.80	2.05	-4.18
(3) Standard Deviation of the Forward Discount	2.07	3.03	2.90
(4) Mean of $(s_t - s_{t-1})$	-0.0018	-0.00019	-0.0032
(5) Standard Deviation of $(s_t - s_{t-1})$	0.0357	0.03511	0.0373
(6) Mean of $(f_{t-1} - s_{t-1})$	-0.0033	0.00161	-0.0036
(7) Standard Deviation of $(f_{t-1} - s_{t-1})$	0.0018	0.00247	0.0025
(8) Row (5) $\div$ Row (7)	19.8	14.6	14.9

Notes and Sources: The spot and forward exchange rates, s_t and f_t , are in logarithms with the time interval equal to one month. The inflation rates are from *International Monetary Fund: International Financial Statistics* and the exchange rates are from Bennett T. McCallum, "A Reconsideration of the Uncovered Interest Parity Relationship," *Journal of Monetary Economics*, 33 (1994), pp. 127–130.

Table 2: Inflation Rate Differences and the Forward Discount: Germany, the U.K. and Japan vs. the U.S., 1978:1–1990:7

	GERMANY		U.K.		JAPAN	
Constant	-3.36	-2.73	1.95	1.07	-3.92	-2.03
	(0.204)	(0.259)	(0.255)	(0.364)	(0.254)	(0.416)
Month over month inflation	0.148		0.048		0.084	
rate difference	(0.041)		(0.034)		(0.033)	
Year over year inflation		0.335		0.508		0.637
rate difference		(0.065)		(0.144)		(0.106)
Number of Observations	151	151	151	151	151	151
R-Square	.078	.152	.013	.078	.042	.194
Standard Error	1.99	1.91	3.02	2.92	2.84	2.61
Durbin-Watson	0.548	0.530	0.247	0.252	0.264	0.253

Notes and Sources: The dependent variable is the forward discount of the domestic currency in terms of the U.S. dollar. The figures in brackets are the standard errors of the coefficients. See Table 1 for sources.

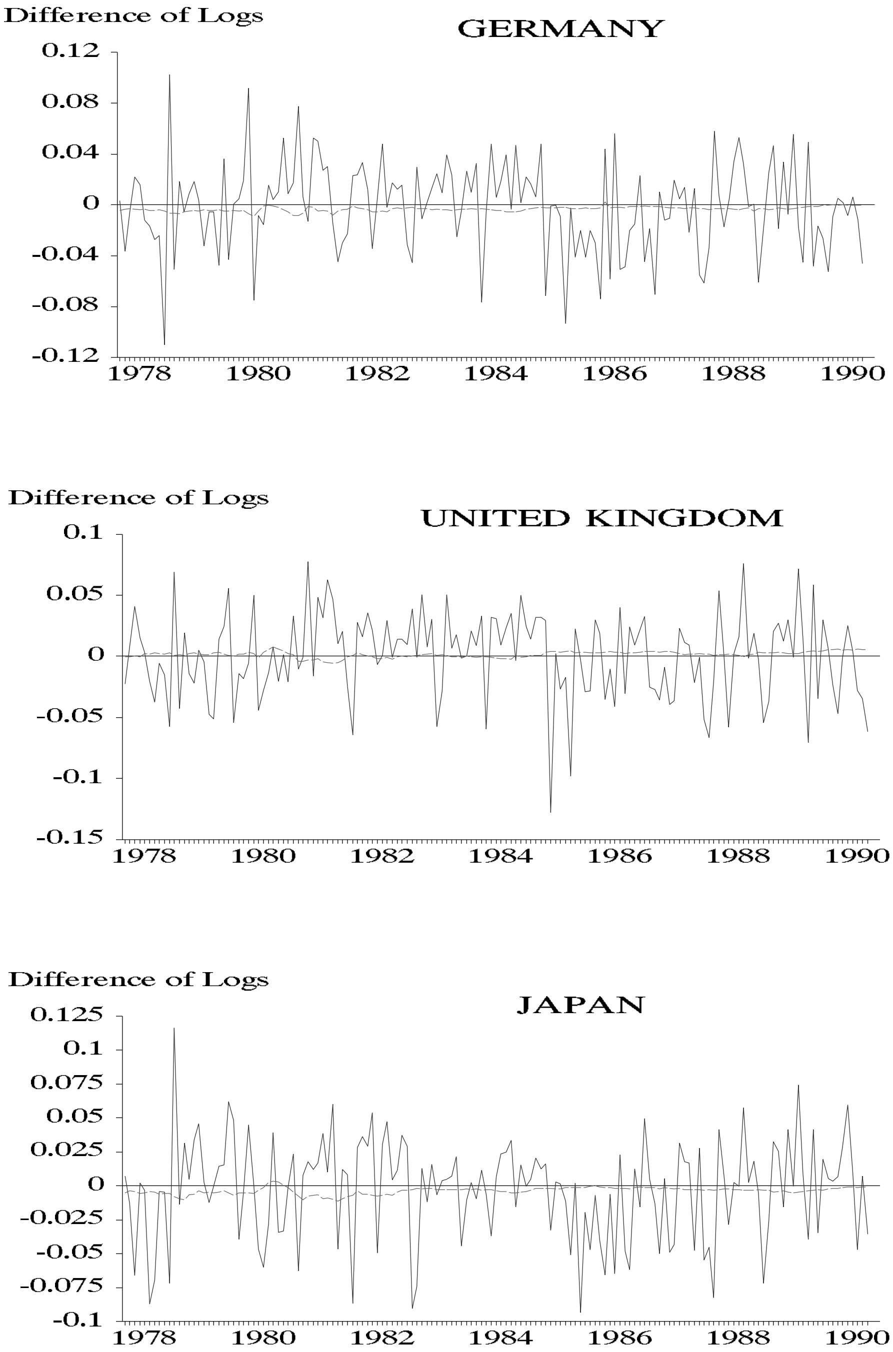

Figure 4: Change in the logarithm of the domestic currency spot price of the U.S. dollar from last period to this period (*solid line*) and the logarithm of last period's forward price minus the logarithm of last period's spot price (*dotted line*): Germany, the United Kingdom and Japan, 1978–1990. Source: See Table 1.

Table 3: The Forward Discount and Interest Rate Differential as Predictors of the Future Spot Rate: Germany, the U.K. and Japan vs. the U.S., January 1978—July 1990

	GERMANY		U.K.		JAPAN	
Constant	-0.013	0.002	0.008	0.0003	-0.0155	-0.003
	(-.006)	(0.004)	(0.003)	(0.003)	(0.005)	(0.003)
Last period's forward discount	-3.38		-4.74		-3.38	
	(1.62)		(1.09)		(1.174)	
Last period's interest rate differential		0.001		0.00004		0.00007
		(0.0007)		(0.0004)		(0.0004)
No. of Obs.	151	151	151	151	151	151
R-Square	.028	.024	.111	.00008	.053	.0002
Standard Error	0.035	0.035	0.035	0.035	0.036	0.037
Durbin-Watson	2.20	2.09	2.21	1.94	2.02	1.91

Notes and Sources: The dependent variable is the change in the logarithm of the spot price of the U.S. dollar from the previous period. The forward discount is calculated from logarithms of the forward and spot rates. The figures in brackets are the standard errors of the coefficients. See Table 1 for sources.

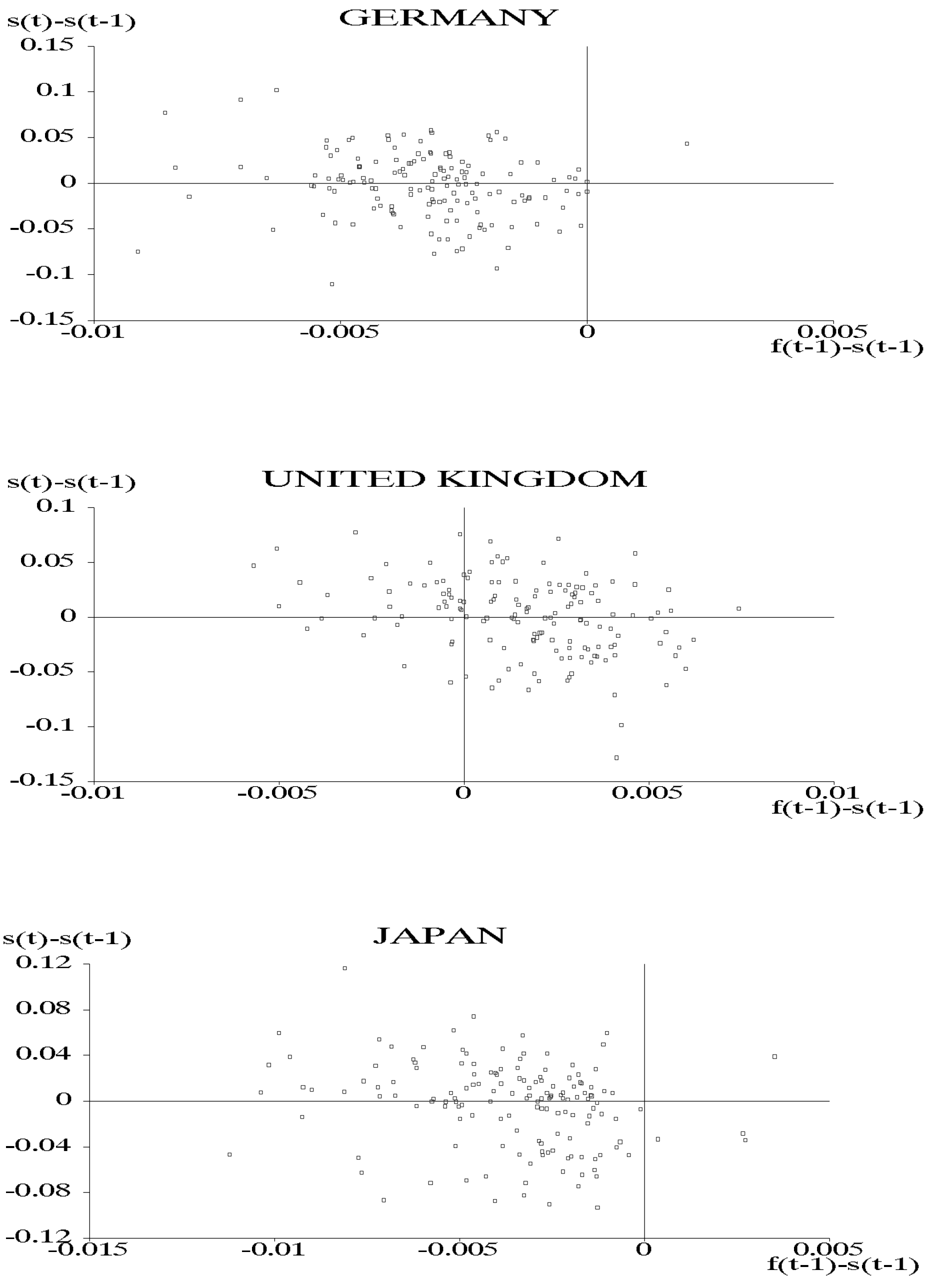

Figure 5: Change in the logarithm of the domestic currency spot price of the U.S. dollar from last period to this period (*vertical axis*) and the logarithm of last period's forward price minus the logarithm of last period's spot price (*horizontal axis*): Germany, the United Kingdom and Japan, 1978–1990. Source: See Table 1.

Table 4: Arbitrage Gains from Exploiting Negative β-Values as of Jan. 1: Percent of Monthly Forward Commitment

	DM	POUND	YEN
Trans. Costs = 0.1% (1.2%)			
1978	0.00	0.00	0.00
1980	-7.81	19.81	8.66
1982	18.28	26.21	12.46
1984	38.79	46.41	22.66
1986	39.14	73.81	17.56
1988	31.27	94.54	-1.44
1990	30.23	88.48	6.66
Trans. Costs = 0.2% (2.4%)			
1978	0.00	0.00	0.00
1980	-9.85	17.77	6.62
1982	14.66	22.59	8.84
1984	32.91	40.53	16.67
1986	31.14	65.80	9.55
1988	21.37	84.64	-11.34
1990	20.57	78.82	-2.99
Trans. Costs = 0.3% (3.7%)			
1978	0.00	0.00	0.00
1980	-11.89	15.73	4.58
1982	11.04	18.96	5.22
1984	27.02	34.64	10.90
1986	23.13	57.80	1.54
1988	11.47	74.74	-21.24
1990	10.91	69.16	-12.65
Trans. Costs = 0.4% (4.9%)			
1978	0.00	0.00	0.00
1980	-13.93	13.69	2.54
1982	7.41	15.34	1.60
1984	21.13	28.75	5.00
1986	15.12	49.79	-6.47
1988	1.57	64.84	-31.14
1990	1.26	59.51	-22.31
Trans. Costs = 0.5% (6.2%)			
1978	0.00	0.00	0.00
1980	-15.97	11.65	0.49
1982	3.79	11.72	-2.02
1984	15.25	22.87	-0.88
1986	7.10	41.78	-14.48
1988	-8.33	54.94	-41.04
1990	-8.40	49.85	-31.97

Note: Transactions costs are expressed as percentage of the monthly forward commitment. Figures in brackets are equivalent annual interest rate premia.