Does Intervention Explain the Forward Discount Puzzle?

by William P. Osterberg

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Introduction

Although neither the Federal Reserve System nor the U.S. Treasury has intervened in foreign exchange markets since August 1995, the policy has not been officially abdicated by the United States, Germany, or Japan.[1] Several Southeast Asian central banks have conducted interventions recently in an attempt to maintain exchange-rate pegs and counter the volatility associated with capital flows. This implies a belief that intervention can alter either the level or the volatility of exchange rates.[2]

A large body of research, however, questions intervention's usefulness, generally finding that the policy has consequences that seem to vary with the period being studied, effects that are inconsistent with the theoretical mechanisms through which intervention might operate, and ultimately, little impact. Such findings must be evaluated in light of the general failure of economic theories of exchange-rate movements when it comes to explaining actual rates. Unfortunately, most central banks provide little day-to-day information about intervention actions, making it difficult to test hypotheses about intervention's effectiveness. This lack of data supports speculation that intervention might explain some of the anomalies in international finance.

Recent research has provided insight into one such anomaly—the forward discount puzzle. This refers to the finding that the currencies of countries with high interest rates appreciate in value, instead of declining, as uncovered interest parity (UIP) might imply. The relevance of the relationship between interest-rate differentials and movements in currency values is obvious from even a casual perusal of the financial press' analyses of currency market developments. These stories usually explain currency appreciations in terms of unexpected economic strength, which would imply higher short-term interest rates. One might be tempted to conclude that the financial press accepts the

■ 1 By law, the Treasury could intervene alone. Typically, however, the Treasury and the Federal Reserve act together and with equal authority. All official exchange-market transactions are conducted by the Federal Reserve Bank of New York, which maintains one account for the Treasury and one for the Federal Reserve (see Humpage [1994] for further discussion).

■ 2 It is not clear at this time whether the 1997 intervention operations conducted by Southeast Asian central banks were sterilized so as to have no direct impact on monetary aggregates. Unsterilized intervention is not distinct from monetary policy.

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anomaly as fact.[3] The forward discount puzzle can also be described as the finding that the forward rate on foreign exchange predicts the wrong direction of movement for the spot exchange rate. The myriad studies that have focused on this puzzle have been dominated by issues of statistical inference, although a few papers have demonstrated a role for exchange-rate policies.

In this article, I utilize official data on U.S. and German central bank interventions to examine the connection between these actions and the forward discount puzzle for the German mark/U.S. dollar (DM/$) and Japanese yen/U.S. dollar (Yen/$) exchange rates from 1985 to 1991. This work is motivated partly by the findings of Flood and Rose (1996; henceforth FR) that countries with higher interest rates are more likely to have their currencies appreciate (the forward discount puzzle) if their exchange rate is floating rather than fixed. Another motivation comes from evidence, presented in Baillie and Osterberg (1997), that is consistent with intervention affecting a risk premium in the forward market. Because interventions are often motivated by a desire to influence the level (or volatility) of the exchange rate, by some measures they could be related to the distinction between fixed and floating exchange-rate regimes.[4] I thus estimate regressions of exchange-rate changes on interest-rate differentials for the full sample period and for subperiods when intervention was relatively heavy or when policymakers expressed willingness to intervene. At least for the DM/$, the forward discount puzzle is stronger during the interventionist subperiods. This appears to strengthen FR's finding that policy is an important determinant of exchange rates' response to interest-rate differentials.

This article is organized as follows: Section I reviews the relevant portion of the literature analyzing the impact of central bank intervention. Section II summarizes recent studies of the forward discount puzzle, including some papers that suggest a role for intervention. Section III discusses the data and the simple analytical framework used here to discover if intervention might explain a portion of the puzzle. Section IV presents the results, and section V states the conclusions.

I. Evidence on the Impact of Central Bank Intervention

Thorough summaries of evidence on the impact of central bank intervention are provided by Edison (1993) and Almekinders (1995). Typically, U.S. intervention operations are sterilized by an offsetting transaction with government securities that leaves the monetary aggregates unaffected. Because nonsterilized intervention can be considered a form of monetary policy, most research has focused on sterilized intervention, which is usually thought to operate either through a portfolio balance channel or by giving the marketplace signals of future government policies. In the former case, the magnitude of an intervention's impact is predicted to depend on the size of the intervention relative to the portfolios of investors choosing between government debt denominated in different currencies.[5] Given the immensity of currency holdings, it is perhaps not surprising that researchers have usually found no significant portfolio balance effect. The signaling channel would be operative if the intervening authorities had information not already available to the market. Such information might take the form of economic data, which, if public, would suggest a higher market value for the currency. The information could also take the form of policy intentions to boost the value of the currency.

Generally, evidence regarding the portfolio balance channel has been negative. Although some impact is found, the coefficients' signs are often inconsistent with the theory, one implication of which is that purchases of domestic currency—and the offsetting sales of domestic government securities—could induce investors to hold relatively more domestic securities only if the domestic currency increased in value. However, the empirical performance of models of the risk premium in foreign exchange rates has generally been unsatisfactory.

■ 3 On the other hand, as can be inferred from equation (1), UIP directly implies that interest differentials correspond only to expected exchange-rate movements, not to actual movements. Thus, an apparently anomalous increase in the currency value might itself be associated with an expected depreciation that is greater than before.

■ 4 However, it is unclear what measure of intervention is relevant in this context. Obvious candidates include the frequency of intervention and its magnitude.

■ 5 The portfolio balance theory rests on two key assumptions: first, that investors view bonds of different currency denominations as imperfect substitutes, and second, that Ricardian equivalence does not hold.

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Research on the signaling channel has had little more success in explaining the comovements of intervention, monetary aggregates, interest rates, and exchange rates. This likewise might not seem surprising, considering the failure of monetary models of exchange-rate determination. After all, if monetary policy has little predictive power for exchange rates, why should we expect intervention's impact on exchange rates to be consistent with the future monetary decisions that intervention implies? The signaling mechanism does not make sense unless the impact of intervention on exchange rates (for example, U.S. authorities buying German marks with U.S. dollars, thus increasing DM/$) is generally consistent with subsequent monetary policy (such as decreased U.S. interest rates). Klein and Rosengren (1991) find no predictable relationship between intervention and monetary policy, and Kaminsky and Lewis (1996) report that intervention's impact on exchange rates is sometimes inconsistent with the monetary policy it appears to signal.[6]

II. Recent Research on the Forward Discount Puzzle

The forward discount puzzle can be understood by considering two separate relations. Equation (1) states UIP that equates the expected gross return at time t from investing one U.S. dollar for a period of length k at rate $r_{t,k}$ with the expected gross return from converting the dollar to a foreign currency (at rate s_t, which denotes foreign currency units per dollar), investing the proceeds at the foreign rate $r_{t,k}{}^*$, and converting back to U.S. dollars at the future exchange rate s_{t+k}.[7]

$$(1) \qquad E_t(1 + r_{t,k}) = E_t[s_t(1 + r_{t,k}{}^*)/s_{t+k}].$$

In this equation, only the future exchange rate is unknown, and E_t refers to the expectation based on knowledge available at time t.

A second relation defines the risk premium as the difference between the expected future spot exchange rate and the current forward rate that would settle on the same date as the future spot rate. Thus, the difference between the actual future spot rate and the forward rate equals the risk premium plus an error term equaling the difference between the actual and expected future spot rates ($u_{t,k}$):

$$(2) \qquad s_{t,k} - f_{t,k} = \rho_{t,k} + u_{t,k}.$$

In (2), s and f refer to the logarithms of the spot and forward rates.

Equation (1) is often rewritten as

$$(3) \qquad s_{t+k} - s_t = r_{t,k}{}^* - r_{t,k} + v_{t,k},$$

where s and r are in logarithms, and v reflects the difference between the actual and expected future spot rate. UIP is usually tested by estimating (4):

$$(4) \qquad s_{t+k} - s_t = \alpha + \beta_r(r_{t,k}{}^* - r_{t,k}) + v_{t,k}.$$

The forward discount puzzle is that β_r, estimated from (4), is usually negative instead of being equal to +1, as implied by (3). The findings regarding (4) are closely related to the findings when the following version of equation (2) is estimated:[8]

$$(5) \qquad s_{t+k} - s_t = \alpha + \beta_f(f_{t,k} - s_t) + u_{t,k}.$$

As Engel (1996) carefully documents, econometric estimates of β_f are often negative and almost always significantly different from +1. Recent research, however, has advanced intriguing possibilities for explaining the puzzle.[9] For example, Baillie and Bollersev (1997) demonstrate that the apparently anomalous estimates of β_f might result from a combination of persistent autocorrelation in the forward premium and the small size of the samples typically studied. FR also provide evidence on the importance of the sample when they estimate (4) with pooled data for exchange rates within the exchange-rate mechanism (ERM) of the European Monetary System. The estimate of β_r declines when periods of realignment are excluded. This implies that the forward discount puzzle might be explained partly by using samples in which realignments are anticipated more

■ 6 A recent analysis of U.S. intervention in the 1990s (Humpage [1997]) concludes that the authorities apparently had no information superior to that of the market. Such a finding is generally inconsistent with the view that intervention signals new information about future monetary policy.

■ 7 Here, "uncovered" refers to the fact that the risk posed by uncertainty about the future exchange rate has not been eliminated (covered) through use of a forward contract or other instrument. In covered interest parity (CIP), the expected future exchange rate in (1) is replaced by the forward rate.

■ 8 Adding $f_{t,k} - s_t$ to both sides of (2) yields (5) if the risk premium equals 0, $\alpha = 0$, and $\beta = 1$. Hence, rejecting $\alpha = 0$ and $\beta = 1$ is often seen as indicating the existence of a risk premium in the forward market.

■ 9 Another promising line of research utilizes term structure models. See Bansal (1997).

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FIGURE 1

Exchange-Rate Changes and Interest-Rate Differentials: DM/$

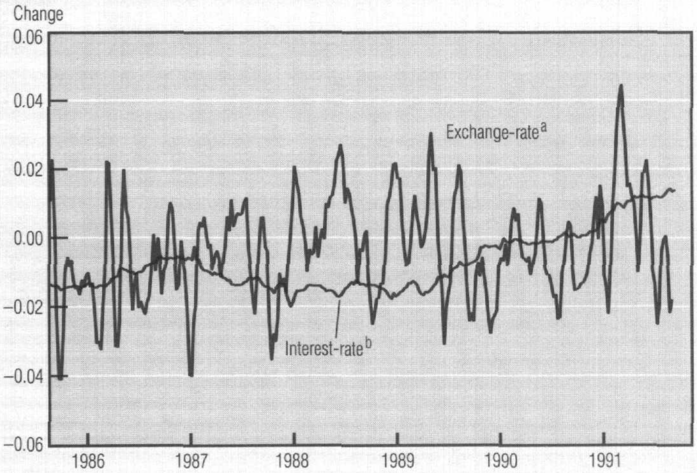
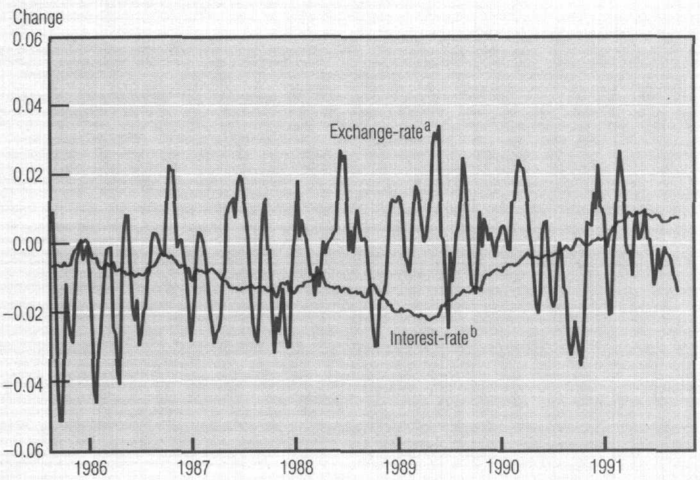


FIGURE 2

Exchange-Rate Changes and Interest-Rate Differentials: Yen/$



a. Calculated as log [$s\,(t+k)$] – log [$s\,(t)$].
b. Calculated as log [$1 + i^*(t)$] – log [$1 + i^*(t)$].
SOURCE: Author's calculations.

frequently than they occur. This phenomenon is often referred to as the "peso problem."

That monetary policy—or exchange-rate policy—could help explain the anomaly is suggested by the financial press' interpretations of short-term movements in exchange rates. News of unanticipated economic strength is said to bolster a currency's value because interest rates are expected to increase, implying the relevance of expected monetary policy. Obviously, any correlation between interest-rate and exchange-rate movements would also be affected by interventions that successfully prevent currency appreciation.

At least three studies suggest that exchange-rate policy might provide a partial explanation of the anomaly. FR estimate (4) using floating-rate data for several currencies' quotes against the dollar, and also using fixed-rate data for currencies within the ERM, quoted against the German mark. Their finding that estimates of β_r became more positive for the fixed-rate data suggests the importance of exchange-rate regimes.

The analysis of (2) in Baillie and Osterberg (1997) shows that central bank intervention influenced risk in the forward market. This points to the existence of a risk premium that can be explained partly by central bank operations. Loopesko (1984) finds that central bank intervention sometimes has explanatory power for deviations from the UIP condition in equation (1).[10] Taken together, these findings suggest that intervention might be related to the forward discount anomaly. For example, if intervention is interpreted as an attempt to "fix" or control exchange rates, then periods of heavy intervention might be associated with more positive estimates of β_r.

III. The Data and the Analytical Framework

To see if the sign of the estimate of β_r varies among periods of light versus heavy intervention, I use the official daily intervention data supplied by the Board of Governors of the Federal Reserve System and the Deutsche Bundesbank, in combination with 9:00 a.m. New York quotes on DM/$ and Yen/$, as well as 3:00 p.m. London 30-day Euromarket interest rates. Figures 1 and 2 depict movements in the logarithm of exchange rates and in the difference in the logarithms of interest rates. The intervention series equal the net sales or purchases of U.S. dollars vis-à-vis the foreign currency over the 24-hour period between consecutive business day closings.

■ **10** Other analyses of the impact of central bank intervention on UIP are summarized by Edison (1993).

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TABLE 1

Intervention and Uncovered Interest Parity: DM/$

Generalized-Method-of-Moments Estimates of Equation (4)

	α (t-statistic)	β (t: $\beta = 0$)	Description
Sample criterion: By intervention			
9/23/85–11/12/85	−0.13 (−3.6)	−3.4 (−3.1)	Plaza Accord
3/23/87–5/4/87	−0.18 (−6.9)	−6.7 (−7.0)	Louvre Accord
8/4/87–9/9/87	−0.27 (−8.8)	−9.2 (−9.5)	*
10/20/87–1/11/88	−0.13 (−4.3)	−3.2 (−4.3)	After 10/87 crash
6/9/88–9/27/88	−0.32 (−5.5)	−10.0 (−6.1)	*
12/20/88–2/7/89	−0.25 (−10.2)	−7.5 (−10.4)	*
4/25/89–6/30/89	−0.41 (−10.2)	−14.3 (−13.7)	*
8/11/89–10/11/89	−0.02 (−1.5)	0.6 (0.6)	*
8/6/85–end	−0.01 (−1.5)	0.06 (0.3)	Full sample
Sample criterion: EMS realignments[a]			
8/6/85–3/27/86	0.08 (0.85)	3.25 (1.1)	
4/21/86–7/25/86	−0.03 (−0.3)	−0.22 (−0.1)	
8/18/86–12/31/87	0.03 (0.5)	3.95 (0.8)	
1/26/87–12/29/89	−0.04 (−4.0)	−1.46 (−3.6)	
1/22/90–5/16/90	0.02 (5.8)	7.7 (5.2)	
8/6/85–5/15/90	−0.02 (−3.0)	−0.6 (−1.8)	

Intervention Data (Number of observations)

	Total	Unilateral	Coordinated	Buy/Sell
Sample criterion: By intervention				
9/23/85–11/12/85	35	19	8	0/27
3/23/87–5/4/87	28	3	1	4/0
8/4/87–9/9/87	26	6	4	5/5
10/20/87–1/11/88	55	10	17	30/0
6/9/88–9/27/88	76	28	29	0/57
12/20/88–2/7/89	33	15	12	0/27
4/25/89–6/30/89	45	10	16	0/25
8/11/89–10/11/89	42	11	14	0/25
8/6/85–end	1,485	283	30	107/206
Sample criterion: EMS realignments[a]				
8/6/85–3/27/86	157	26	8	6/28
4/21/86–7/25/86	64	10	0	10/0
8/18/86–12/31/87	90	8	0	7/1
1/26/87–12/29/89	720	113	105	56/162
1/22/90–5/16/90	79	2	2	0/2
8/6/85–5/15/90	1,167	253	26	83/196

a. See Flood, Rose, and Mathieson (1991).
NOTE: Asterisks indicate periods of relatively heavy intervention. Numbers in parentheses are t-statistics.
SOURCE: Author's calculations.

The sample period extends from August 6, 1985 through September 6, 1991, a period that includes two well-publicized Group of Three (G-3) attempts to influence dollar exchange rates.[11] The Plaza Accord in September 1985 stipulated that the G-3 countries' central banks would intervene to bring down the level of the dollar, and the Louvre Accord of February 1987 included statements that central banks would strive to reduce fluctuations in the dollar. Other periods of intervention were defined by examining the actual intervention time series. These periods were characterized by relatively heavy or consistent intervention by one or two of the central banks.

We utilize a generalized-method-of-moments (GMM) technique to account for the fact that the error term appearing on the right side of (3) has a high-order moving average representation because the data are daily observations on a

■ 11 G-3 refers to the three largest industrialized countries—Germany, Japan, and the United States.

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TABLE 2

Intervention and Uncovered Interest Parity: Yen/$

Generalized-Method-of-Moments Estimates of Equation (4)

	α (t-statistic)	β(t: β = 0)	Description
Sample criterion: By intervention			
9/23/85–11/12/85	−0.02 (−2.0)	3.1 (4.9)	Plaza Accord
4/16/86–8/7/86	0.09 (2.6)	5.8 (2.6)	*
3/24/87–4/27/87	−0.3 (−6.3)	−11.3 (−6.6)	Louvre Accord
8/13/87–9/9/87	0.13 (2.9)	3.9 (2.7)	*
10/27/87–1/21/88	0.08 (−1.1)	−2.3 (−1.1)	After 10/87 crash
3/15/88–4/20/88	−0.02 (−2.9)	−0.9 (−3.4)	*
10/27/88–12/8/88	−0.08 (−1.8)	−2.3 (−2.4)	*
4/28/89–7/21/89	0.26 (4.1)	7.0 (3.9)	*
8/7/89–10/12/89	0.08 (4.5)	3.2 (4.2)	*
2/23/90–4/19/90	0.27 (5.4)	28.8 (5.7)	*
8/6/85–9/6/91	−0.01 (−2.4)	−0.2 (−1.1)	Full sample

Intervention Data (Number of observations)

	Total	U.S. Buy	U.S. Sell
Sample criterion: By intervention			
9/23/85–11/12/85	34	0	20
4/16/86–8/7/86	76	0	0
3/24/87–4/27/87	23	16	0
8/13/87–9/9/87	19	5	4
10/27/87–1/21/88	57	22	0
3/15/88–4/20/88	25	5	0
10/27/88–12/8/88	28	13	0
4/28/89–7/21/89	56	0	34
8/7/89–10/12/89	47	0	28
2/23/90–4/19/90	38	0	13
8/6/85–end	1,464	66	116

NOTE: Asterisks indicate periods of relatively heavy intervention. Numbers in parentheses are t-statistics.
SOURCE: Author's calculations.

one-month interest-rate contract. I have matched the future spot rate with the one-month Eurocurrency interest rate so that both settle on the same day. As Baillie and Osterberg (1997) point out, this implies an MA(21) representation. The standard errors used to calculate the t-statistics in the tables are also corrected for heteroscedasticity. The instrumental variables chosen are a constant, the lagged interest-rate differential, and the lagged change in the logarithm of the exchange rate. Hamilton (1994, chapter 10) provides a useful review of the issues involved in GMM estimation.

IV. Results

Table 1 presents the results of estimating equation (4) for the DM/\$. For the entire sample period, the estimate of β is slightly positive but significantly less than one. The finding that the coefficient is slightly positive is unusual, indicating that the results may be sensitive to the sample. However, for seven of the eight intervention periods, the estimate of β is not only significantly different from one but also significantly negative.[12] For comparison with FR, I estimated equation (3) for the periods between EMS realignments. Unlike FR, I find that the sign of the estimated β does not seem to depend on whether these periods are excluded from estimation. However, the realignments and the analysis in FR pertain to exchange rates of the European currencies vis-à-vis the German mark. Apparently, the ERM realignments were not reflected in the DM/\$ or in the U.S. and German interventions vis-à-vis the DM/\$.

Table 2 presents similar results from estimating equation (4) for the Yen/\$. The full-sample-period estimate of β is negative and significantly different from one. However, the results for the subperiods provide less encouragement that intervention could somehow explain the forward discount puzzle: In only four of the 10 subperiods were the estimates of β significantly negative. It is interesting that, in six of these intervals, the estimate was significantly greater than one.[13] Overall, for the two currencies, 11 of the 18 subperiods showed estimates of β_i that were significantly less than zero.

■ 12 These results appear to be robust to slight variations in the length of the intervention periods.

■ 13 On the other hand, when I estimate the same equation for the full sample period, including intercept and slope dummies equal to one for the intervention periods, both dummies differ significantly from zero.

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The second half of each table provides summary data on U.S. and/or German intervention. In table 2, only official information about U.S. intervention against the yen is available. Baillie and Osterberg (1997) find evidence consistent with the idea that U.S. buying—but not selling—of dollars affects risk in the forward market. Here, I find that in the case of the DM/$, β is negative whether the intervention activity was buying or selling. In the case of the Yen/$, on the other hand, buying dollars is associated with a negative estimate of β, while selling implies a positive estimate.

V. Conclusion

My evidence on the importance of intervention for the forward discount puzzle is strongest for the DM/$. However, whereas FR find that β became positive under fixed-rate regimes, I find significantly negative estimates for intervention periods. This suggests at least a need to clarify the correspondence between my choice of intervention periods and shifts between floating- and fixed-rate regimes. However, the results presented here are even more interesting when one notes that estimated β was also negative for both exchange rates following the Plaza and Louvre agreements. Prior to each of these periods, public statements indicated the likelihood of coordinated efforts to influence exchange rates. Thus, we would have expected the results in both instances to be similar to FR's findings for fixed-rate regimes.

The results also suggest that it would be valuable to examine more closely the hypothesis that buying currencies and selling them have different impacts. It is certainly possible that market conditions have varied between periods of buying and periods of selling. Noise-trading analyses, such as Hung (1997), discuss the relevance of market thinness and the rules followed by chartists.

Of course, recent research on the importance of sample size places rather stringent qualifications on any conclusions I might draw. Unfortunately, few central banks release high-frequency data on intervention, although the recent collapse of fixed-rate regimes and increasing pressure for transparency on the part of central banks might improve opportunities to study the connection between exchange-rate regimes, interest rates, and intervention.

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