Foreign Exchange Intervention as a Signal of Monetary Policy

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Midway through the 1980s, the position of the United States government toward international economic policy coordination shifted significantly. A noninterventionist stance in the foreign exchange market characterized the first half of the decade. This period saw a dramatic appreciation of the dollar, which rose over 50 percent in value against a weighted average of other major currencies between the beginning of 1980 and the beginning of 1985.[1] This large currency movement was accompanied by a large and growing deficit in the U.S. trade account and increasingly strident calls for protectionist legislation.

In the face of mounting concern regarding currency movements, policy shifted in the autumn of 1985 toward an attempt to manage the dollar. The watershed event was a meeting held at New York's Plaza Hotel on September 23, 1985. This meeting brought together central bankers and finance and treasury officials from the five largest industrial countries, the so-called Group of Five (G-5).[2] Over the next two years, the policy coordination initiated at the Plaza meeting continued with an economic summit meeting in Tokyo (May 5, 1986) and a meeting at the Louvre (February 22, 1987). Overall, the two-year period beginning with the Plaza meeting and ending with the worldwide stock market crash on October 19, 1987 marked the highest degree of international economic policy coordination between the United States and other major industrial countries since the advent of floating exchange rates in 1973.

In the wake of the Plaza meeting, the dollar depreciation that had begun in early 1985 but had stalled by late summer resumed apace.[3] This path was consistent with policy goals. The communique issued after the Plaza meeting called for "some further appreciation of the main non-dollar currencies against the dollar" and stated that the G-5 governments would "stand ready to cooperate more closely to encourage this when to do so would be helpful." The dollar had depreciated 15 percent by the time of the Tokyo summit and another 8 percent by the time of

the Louvre meeting. At the Louvre meeting, the policy goal shifted from dollar depreciation to currency stabilization. The eight-month period until the October 1987 stock market crash was the most stable for the major foreign exchange markets since the beginning of floating exchange rates, fourteen years earlier.

The apparent responsiveness of currencies to policy goals during the two-year period following the Plaza meeting has renewed interest in the efficacy of foreign exchange intervention. Most empirical studies of the effectiveness of intervention have concluded that intervention that leaves monetary policy unchanged has no lasting effect on the exchange rate. Despite this empirical finding, central banks may still choose to intervene to stabilize exchange markets or to signal a willingness to alter monetary policy. If central banks intervened to stabilize foreign exchange markets, exchange rate variance would be reduced but the level of exchange rates would remain unchanged. Alternatively, the goals of the central bank or economic circumstances may occasionally require greater emphasis on exchange rate management. Intervention may emphasize to market participants the importance of the exchange rate in policy determination and signal possible future changes in domestic monetary policy. This latter justification for intervention is explored in this article.

While intervention as a signal of monetary policy has been discussed in general terms in the international literature, it has not received a direct empirical testing. This article will examine the possibility that intervention by the United States and West Germany served as a signal of future monetary policy during the period between the Plaza Meeting and the October 1987 stock market crash. The first section discusses the nature of the intervention and the monetary policy changes undertaken by the United States and West Germany during this period. Section II describes the properties of a signal and considers whether intervention served as an effective signal of changes in monetary policy. Examination of the data leads to the conclusion that intervention did not precede monetary policy changes in any regular or predictable manner during this period.

Intervention may emphasize the importance of the exchange rate in policy determination and signal possible future changes in domestic monetary policy.

This finding is not necessarily inconsistent with intervention being perceived as a signal. Participants in the foreign exchange market may have thought at the time (incorrectly, as it turns out) that intervention was providing information about future monetary policy. Had market participants viewed intervention in this manner, a significant correlation would be expected between intervention and the exchange rate. This hypothesis is examined in Section III. Evidence is presented showing that intervention significantly affected the daily change in the exchange rate in the wake of the Plaza meeting. By the time of the Tokyo meeting and for the rest of the sample period, however, no evidence is found that the exchange rate responded to intervention in a significant way. The study concludes that, over time, foreign exchange market participants learned that intervention was not serving as a signal of changes in monetary policy.

I. Intervention and Monetary Policy

Official intervention in foreign exchange markets that leaves the money supply unchanged is called sterilized intervention. Sterilized intervention has no effect on the reserves of the banking system and thus does not alter monetary policy, because it involves a trade by a central bank of securities denominated in one currency for securities denominated in another currency.[4] For example, the Federal Reserve may sterilize a purchase of German securities by concurrently selling U.S. securities. This transaction alters the composition of securities held by the public, but not monetary policy. As a result of the transaction, the public holds more U.S securities and fewer German securities.

Sterilized intervention may affect the exchange rate through two channels: by changing the composition of the denomination of assets held by the public (the portfolio-balance channel), and by signalling central bank intentions on future monetary policy (the signalling channel). The portfolio-balance channel depends upon securities denominated in different currencies being imperfect substitutes. When securities are imperfectly substitutable, the

exchange rates and rates of returns on the securities must change in order to induce the public to hold the new portfolio. This portfolio-balance effect on exchange rates, while theoretically plausible, has not been found to be empirically significant.[5] The lack of a portfolio-balance effect may be due to either the close substitutability of differently denominated securities or the small amount of intervention relative to the outstanding stock of securities.

An alternative rationale for sterilized intervention is that the central bank is signalling a willingness to alter monetary policy.[6] The period examined here, from the September 1985 Plaza Accord to the October 1987 stock market crash, provides an important source of data for testing the role of intervention as a signal. This period stands in marked contrast to the first half of the decade, when the United States engaged in essentially no foreign exchange intervention. In the wake of the Plaza meeting, considerable consultation and coordination occurred among central banks. The importance of international considerations in setting monetary policy during this period is apparent from minutes of Federal Open Market Committee (FOMC) meetings and from descriptions of the Plaza and Louvre meetings.

Monetary Policy in the United States

The Federal Reserve implements monetary policy by altering the availability and cost of bank reserves. The supply of bank reserves can be changed by open market buying or selling of government securities, or through Federal Reserve discount window loans of reserves to banks. The demand for bank reserves depends on the reserve requirements and the amounts of funds held at banks in reservable accounts.

Monetary policy targeted the reserves borrowed by the private banking system from the discount window during the period that included the two years between the Plaza Accord and the 1987 stock market crash. This procedure affected short-term interest rates (in particular, the federal funds rate, which is the rate banks charge for lending bank reserves to other banks), as banks attempted to meet legal reserve requirements. The least costly way for banks to meet their reserve requirements is to borrow directly from the Federal Reserve, since the discount rate is generally below the federal funds rate. Although the Federal Reserve discourages using the discount window as a source of low-cost funds, bank borrowing from the Federal Reserve increases as the spread between the federal funds rate and the discount rate increases. It is this relationship, between bank borrowing and the spread between the federal funds rate and the discount rate, that translates a borrowings target into an expected trading range for the federal funds rate, the short-term interest rate most influenced by monetary policy.

Table 1
Changes in U.S. Monetary Policy, Plaza Accord to Stock Market Crash

Time Period	Borrowings Target ($ million)	Discount Rate (Percent)	Daily Effective Federal Funds Rate (Percent)
9/23/85 – 11/ 5/85	500	7.5	8.18
11/ 6/85 – 12/17/85	450	7.5	8.17
12/18/85 – 2/12/86	350	7.5	8.26
2/13/86 – 3/ 6/86	300	7.5	7.97
3/ 7/86 – 4/17/86	300	7.0	7.40
4/18/86 – 7/ 9/86	300	6.5	7.02
7/10/86 – 8/19/86	300	6.0	6.47
8/20/86 – 4/29/87	300	5.5	6.32
4/30/87 – 5/20/87	400	5.5	6.98
5/21/87 – 9/ 2/87	500	5.5	6.79
9/ 3/87 – 10/16/87	600	6.0	7.51

Source: Federal Reserve Bank of New York.

For each borrowings target an expected spread exists between the discount rate and the federal funds rate. If the borrowings target is unchanged and the discount rate is increased, the spread will be maintained by an increase in the federal funds rate of approximately the same amount. When the discount rate is raised initially, the spread is not wide enough to encourage discount borrowing, so banks bid more aggressively for federal funds. The federal funds rate then rises until the spread is restored to approximately the same level as before the discount rate change. Alternatively, if the borrowings target is raised with no change in the discount rate, the Federal Reserve pushes more banks to the discount window by selling bonds to absorb reserves. The diminished supply of reserves causes banks to bid up the rate on federal funds until enough banks borrow from the discount window to restore equilibrium.

Table 1 shows the prevailing borrowings target, the discount rate, and the federal funds rate at the time of changes in U.S. monetary policy between the Plaza Accord and the October 1987 crash. These data

show that monetary policy was easing, with drops in both the borrowings target and the discount rate, from September 1985 until April 1987. Monetary policy tightened from April 1987 until October 1987, with the average federal funds rate increasing almost 120 basis points over the final six months of the sample. The data in the table also demonstrate that reductions in the discount rate when the borrowings target was constant resulted in drops in the average federal funds rate of approximately the same magnitude. The relationship between changes in the borrowings target and the federal funds rate is less clear, in part because of technical problems during this period. The decrease in the borrowings target on February 13, 1986 and the increases on April 30, 1987 and September 3, 1987 all resulted in the average federal funds rate moving in the expected direction. Two decreases in borrowings at the end of 1985 did not result in a significant drop in the rate. Other factors at that time such as Hurricane Gloria, debt ceiling restrictions, and a major clearing house disruption caused the average federal funds rate to trade higher than anticipated. The failure of the average federal funds rate to increase after the May 21, 1987 policy change, however, cannot be attributed to any specific factors.

Table 2
Changes in German Monetary Policy, Plaza Accord to Stock Market Crash

Time Period	Discount Rate (Percent)	Lombard Rate (Percent)	Repurchase Rate (Percent)
9/23/85 – 9/24/85	4.0	5.5	4.60
9/25/85 – 12/ 3/85	4.0	5.5	4.55
12/ 4/85 – 1/ 7/85	4.0	5.5	4.60
1/ 8/86 – 1/21/86	4.0	5.5	4.55
1/22/86 – 3/ 4/86	4.0	5.5	4.50
3/ 5/86 – 3/ 6/86	4.0	5.5	4.30
3/ 7/86 – 4/ 2/86	3.5	5.5	4.30
4/ 3/86 – 11/11/86	3.5	5.5	4.35
11/12/86 – 12/ 2/86	3.5	5.5	4.40
12/ 3/86 – 12/ 9/86	3.5	5.5	4.60
12/10/86 – 1/ 6/87	3.5	5.5	4.65
1/ 7/87 – 1/22/87	3.5	5.5	4.60
1/23/87 – 2/ 3/87	3.0	5.0	4.60
2/ 4/87 – 5/12/87	3.0	5.0	3.80
5/13/87 – 7/21/87	3.0	5.0	3.55
7/22/87 – 9/22/87	3.0	5.0	3.60
9/23/87 – 10/ 6/87	3.0	5.0	3.65
10/ 7/87 – 10/13/87	3.0	5.0	3.75
10/14/87 – 10/20/87	3.0	5.0	3.85

Source: Data Resources, Inc., and *Report of the Deutsche Bundesbank.*

Monetary Policy in West Germany

The direction of German monetary policy can be ascertained from three interest rates: the discount rate, the Lombard rate, and the repurchase rate. Repurchase agreements are the primary instrument for implementing monetary policy in Germany. Repurchase agreements involve a transaction by the German central bank (the Bundesbank) that is reversed in the near future; for example, the Bundesbank may buy securities and agree to resell them in a month. In general, the initial transaction of a repurchase agreement is reversed after approximately one month, though longer repurchase agreements are made at slightly higher rates.

The discount rate is the rate at which universal banks sell securities, such as bills of exchange and treasury bills, to the Bundesbank.[7] It differs from the U.S. discount rate in three ways. First, the discount loan in the United States is a collateralized loan set at a subsidized rate while the German discounting involves the sale of securities. German universal banks profit on the spread between the rate paid on the securities and the lower discount rate paid to the Bundesbank. Second, while U.S. discount borrowing by banks is expected to occur infrequently, to meet reserve needs of the financial institution, the German universal banks are expected to fully utilize their discount quotas. Third, while U.S. monetary policy incorporates expected discount borrowing into the system as a whole, no attempt is made to encourage particular institutions to borrow from the discount window. German discount policy sets quotas on discount loans for the system and for each individual bank according to a complicated formula that considers factors such as individual bank capitalization and loan structure. The German discount rate is adjusted relatively infrequently, and was changed only twice in our two-year sample.

The Lombard rate is the rate the Bundesbank offers on loans with collateral of qualified securities. Lombard loans are more analogous to the Federal Reserve discount window loans. They are both collateralized loans intended to meet the liquidity needs of the financial system, though the Lombard rate is a penalty rate rather than a subsidized rate. The Lombard loan has three major differences from German discount lending: the rate is set above market rates,

financial intermediaries besides universal banks have access to Lombard lending, and the Lombard loan provides short-term financing on an occasional basis. The Lombard rate moved only once during our sample and this was in conjunction with one of the two changes in the discount rate.

Table 2 shows the timing and magnitude of changes in indicators of German monetary policy. The first of the two discount rate reductions during our sample occurred immediately following a drop in the discount rates in the United States. The second discount rate reduction occurred at the same time as the reduction in the Lombard rate. The repurchase rate changed sixteen times, but only six of these represented a change of more than 5 basis points. The repurchase rates were generally falling through most of the sample period, with the largest drops occurring around the time of the drops in the Lombard and discount rates, although repurchase rates were trending upward in the five months prior to the October 1987 stock market crash.

II. *Intervention as a Signal*

Central to a discussion of intervention as a signal of monetary policy are its effectiveness and its relevance. For intervention to serve as an effective signal of monetary policy, it should precede future actions in a proximate and consistent manner. The effectiveness of intervention as a signal will be eroded by signalling failures, that is, interventions that are not followed by changes in monetary policy and policy changes that are not preceded by intervention. In order to be a relevant signal, intervention should disclose information that the market would otherwise not have. If the information provided by intervention were redundant (if, for example, interventions were always fully anticipated), then it would serve no role as a signal.

This section will assess the ex post effectiveness of intervention as a signal of monetary policy by examining the temporal relationship between intervention and monetary policy changes.[8] The intervention data used are reports of intervention by the Federal Reserve or the Bundesbank that appeared in *The Wall Street Journal*, *The New York Times*, and the *Financial Times* of London. These intervention data serve the purpose of this study better than actual intervention data (which are confidential and difficult to obtain), since intervention serves as a signal only when it is widely observed by the market.

Table 3 summarizes the number of interventions reportedly undertaken by the Federal Reserve and the Bundesbank for the entire sample period as well as for three subperiods. The Bundesbank was much more active in the foreign exchange market than the Federal Reserve. The Bundesbank was reported to have intervened twice as many times as the Federal Reserve, with more than two-thirds of its actions occurring unilaterally. The Federal Reserve was reported to have intervened on 34 trading days out of the 532 trading days in the sample. Of those 34 interventions, nearly two-thirds were conducted in conjunction with the Bundesbank. Most joint interventions occurred immediately after the Plaza Accord and in the period following the Louvre meeting. No joint interventions were reported during the period from the Tokyo meeting to the Louvre meeting. While the Bundesbank intervened unilaterally throughout the period, the Federal Reserve rarely intervened without the Bundesbank, particularly in the period from the Plaza Accord to the Louvre meeting.

Table 3
Number of Days of Reported Dollar Interventions, Plaza Accord to Stock Market Crash

	Dollar Interventions	
Time Period	United States	Germany
Plaza—9/23/85–5/3/86		
Alone	2	19
Together	9	9
Tokyo—5/6/86–2/20/87		
Alone	2	18
Together	0	0
Louvre—2/23/87–10/16/87		
Alone	8	12
Together	13	13
Total	34	71
Alone	12	49
Together	22	22

Source: Intervention reports in *The Wall Street Journal*, *The New York Times*, and *Financial Times* of London.

If intervention signalled changes in monetary policy, then a clustering of interventions would be expected to occur immediately prior to policy changes. Table 4 provides the cumulative number of days that interventions were reported to have oc-

Table 4
Interventions as Signals of Changes in U.S. Monetary Policy

Date of Monetary Policy Change	Type of Change[a]	Number of Federal Reserve Interventions[b] in Previous Trading			Number of Bundesbank Interventions[b] in Previous Trading		
		5 Days	10 Days	15 Days	5 Days	10 Days	15 Days
11/ 6/85	BR d 50	0	1	2	0	4	8
12/ 8/85	BR d 100	0	0	0	0	2,−1	2,−1
2/13/86	BR d 50	0	0	0	0	0	0
3/ 7/86	DR d .50	0	0	0	0	0	0
4/18/86	DR d .50	0	0	0	0	0	0
7/10/86	DR d .50	0	0	0	0	0	0
8/20/86	DR d .50	0	0	0	0	0	0
4/30/87	BR u 100	0	0	−2	−3	−4	−6
5/21/87	BR u 100	0	0	−2	0	0	−2
9/ 3/87	BR u 100 and DR u .50	−3	−3	−4	−3	−3	−3

[a]BR = Borrowed reserves target ($millions), DR = Discount rate (percentage point changes), u = up, d = down.
[b]Positive numbers are $ sales, negative numbers are $ purchases.
Source: See Tables 1 and 3.

curred in the five, ten, and fifteen trading days prior to each change in U.S. monetary policy. Given the number of reported interventions by the Federal Reserve that appear in this sample, the probability of intervention on any particular day is 6 percent. The probability of observing at least one intervention in five trading days is 27 percent, in ten trading days is 48 percent, and in fifteen trading days is 60 percent. The observed numbers of days of interventions that appear in Table 4 are fewer than would be expected if interventions occurred randomly, except for the September 3, 1987 change in policy. Only 10 of the 34 Federal Reserve interventions occurred within 15 trading days of a policy change. Therefore, even if investors initially thought that intervention was signalling future policy changes after the Plaza Accord, the large number of interventions not followed by policy changes and the large number of policy changes not preceded by interventions would have quickly reduced the value of interventions as a signal.

Since two-thirds of the Federal Reserve interventions occurred jointly with the Bundesbank, it is possible that both interventions signalled a change in German rather than American monetary policy. Table 5 shows the number of days the Federal Reserve and the Bundesbank intervened in the 15 trading days prior to German policy changes. Since the sample includes 71 German interventions, if interventions occurred randomly there would be a 13 percent chance of an intervention on any given day. The probability of observing at least one intervention in five trading days is 50 percent, in ten trading days the probability is 75 percent, and in fifteen trading days 88 percent. Again, the number of interventions prior to policy changes is lower than might be expected had intervention occurred randomly. Of the 71 days when German intervention occurred, 53 were not followed by a policy change in the subsequent three weeks. Thus, most interventions were not followed by policy changes and most of the policy changes were not preceded by a significant increase in interventions.

III. Exchange Rates and Intervention: The Role of 'News'

The data presented in the previous section indicate that no consistent and proximate link existed between foreign exchange intervention by the central banks of the United States and West Germany and changes in their respective monetary policies during the period between the September 1985 Plaza meeting and the October 1987 stock market crash. With the benefit of hindsight, one can conclude from these data that intervention did not signal future monetary

policy. The data failed to answer, however, the question of whether the foreign exchange market viewed intervention as a signal at the time. This section will address the issue by examining the effect of intervention and monetary policy changes on the daily deutsche mark/dollar exchange rates.

Modern international finance theory provides a framework for inferring whether market participants viewed intervention as a signal. The framework draws from models of exchange rate determination that focus on the role of the exchange rate as the relative price of assets denominated in different currencies. As with other asset prices, the exchange rate is forward-looking and a function of its own expected future value. This forward-looking characteristic ensures that the exchange rate responds to news about future events. Thus, information about future changes in monetary policy affects the exchange rate immediately. A significant link between exchange rates and interventions is consistent with intervention being viewed during the sample period as a signal of future monetary policy. A failure to find such a link would suggest that the market did not view intervention as a signal, either because the information had already been revealed prior to the intervention or because the intervention was perceived as devoid of information.

Asset-Market Models of the Exchange Rate and the Effect of News

The high degree of integration in international capital markets and the vast daily volume of foreign exchange transactions underscores the importance of viewing the exchange rate as a measure of the relative price of assets denominated in different currencies. Central to this asset-market-based approach to exchange rate determination is the arbitrage relationship of interest parity. This relationship states that assets sharing common liquidity and political risk characteristics but denominated in different currencies have equal expected returns when these returns

Table 5
Interventions as Signals of Changes in German Monetary Policy

Date of Monetary Policy Change	Type of Change[a]	Number of Federal Reserve Interventions[b] in Previous Trading			Number of Bundesbank Interventions[b] in Previous Trading		
		5 Days	10 Days	15 Days	5 Days	10 Days	15 Days
9/25/85	RR d .05	2			2		
12/ 4/85	RR d .05	0	0	0	0	0	0
1/ 8/86	RR d .05	0	0	0	0	−1	−2
1/22/86	RR d .05	0	0	0	0	0	0
3/ 5/86	RR d .20	0	0	0	0	0	0
3/ 7/86	DR d .50	0	0	0	0	0	0
4/ 3/86	RR u .05	0	0	0	0	0	0
11/12/86	RR u .05	0	0	0	0	0	0
12/ 3/86	RR u .20	0	0	0	0	0	0
12/10/86	RR u .05	0	0	0	0	0	0
1/ 7/87	RR d .05	0	0	0	−1	−1	−1
1/23/87	DR d .50 and LR d .50	0	0	0	0	−2	−4
2/ 4/87	RR d .80	0	−1	−1	0	−2	−2
5/13/87	RR d .25	0	−2	−2	0	−2	−5
7/22/87	RR u .05	−1	−1	−1	0	1	2
9/23/87	RR u .05	0	−1	−2	0	0	−2
10/ 7/87	RR u .10	0	0	0	0	0	0
10/14/87	RR u .10	0	0	0	0	0	0

[a]DR = discount rate, LR = Lombard rate, RR = repurchase rate (percentage point changes). u = up, d = down.
[b]Positive numbers are $ sales, negative numbers are $ purchases. Study begins 9/23/85.
Source: See Tables 2 and 3.

are expressed in a common currency. For example, the return on a security denominated in dollars and a security with similar liquidity and political risk attributes denominated in deutsche marks will provide the same expected return when the return on the deutsche mark security is expressed in dollars or when the return on the dollar security is expressed in deutsche marks. This relationship is shown in equation 1.

$$(1) \qquad (1 + R_t) = (1 + R_t^*) \cdot (E_t S_{t+1}/S_t)$$

where R_t is the domestic interest rate on a security that comes due in period $t + 1$, R_t^* is the interest rate on a foreign security with similar risk and liquidity attributes, S_t is the exchange rate at time t (domestic currency per unit of foreign currency) and $E_t S_{t+1}$ is the expectation at time t of the value of the exchange rate at time $t + 1$.[9] This equation can be rewritten as follows:[10]

$$(2) \qquad R_t = R_t^* + [(E_t S_{t+1}/S_t) - 1]$$

where the term in square brackets represents the expected rate of change of the domestic currency.

The expected change in the exchange rate figures into the interest parity relationship because the domestic-currency-denominated return on the foreign currency security depends upon two factors, the interest paid by the foreign currency bond and the change in the exchange rate over the time the security is held. The expected change in the exchange rate is an important determinant of relative returns because it affects the amount of domestic currency the bearer of the foreign-currency security can purchase when the security matures. For example, a person who purchases a deutsche-mark-denominated security with a relatively strong dollar and later receives coupon payments in relatively strong deutsche marks enjoys the greater purchasing power of the coupon payments due to the depreciation of the dollar.

The interest parity relationship in equation 1 illustrates how sterilized intervention may affect the exchange rate. A sterilized intervention has no effect on the domestic or foreign money supply and thus it has no effect on either R_t or R_t^*. If intervention is a signal of future monetary policy it will affect the expected future value of the exchange rate, $E_t S_{t+1}$. Equation 1 demonstrates that, given foreign and domestic interest rates, interest parity will continue to hold, with a change in the expected future exchange rate only if today's spot exchange rate also changes in the same direction and by the same magnitude. Thus, news about future policy affects the exchange rate today, through its effect on the expected future exchange rate.

This heuristic explanation of the effects of intervention on the current spot exchange rate through its role as a signal of future monetary policy obviously glosses over some important complications. Nevertheless, the basic intuition provided by this example continues to hold in a fully specified model.[11] One result apparent from a fully specified model that is not immediately obvious from inspection of equations 1 and 2 is that an anticipated change in monetary policy can occur at any point in the future and still affect the exchange rate as soon as the information is revealed. A caveat to this point is that the effect of a given change in monetary policy is larger, the closer to the present it occurs. Finally, it is important to mention that news about monetary policy in either country will affect the exchange rate. If the expected change in monetary policy is the same in both countries the exchange rate may not be affected.

For intervention to serve as an effective signal of monetary policy, it should precede future actions in a proximate and consistent manner.

An Empirical Test of the Effects of Intervention on the Exchange Rate

This section will investigate the effect of intervention by the Federal Reserve and the Bundesbank on the daily deutsche mark/dollar exchange rate. The tests cover three subsamples of the period between the September 1985 Plaza meeting and the October 1987 stock market crash: the period between the Plaza meeting and the May 1986 Tokyo summit meeting, the period between the Tokyo summit and the February 1987 Louvre meeting, and the period following the Louvre meeting until the stock market crash.

The sample is divided into subperiods in order to discern whether the credibility of intervention as a signal evolved over time in the way suggested by the previous discussion. The commitment to manage the exchange rate, mentioned in the communique from the Plaza meeting, may have initially given credibility

to the use of intervention as a signal. In this atmosphere one would expect to find that intervention has a significant effect on the exchange rate. As participants in the foreign exchange market learned of the lack of a proximate and consistent link between intervention and monetary policy, however, the effect of intervention on the exchange rate would erode.[12]

The discussion in the previous section suggested a framework for specifying an empirical test for the effects of intervention on the exchange rate. If intervention were perceived to be a signal of future monetary policy change, then it would have an immediate impact on the exchange rate. If, on the other hand, intervention were not perceived as a signal, then it would not significantly alter the exchange rate. A regression was estimated to test this hypothesis.

The dependent variable in the regression equation tested is the logarithm of the change in the deutsche mark/dollar exchange rate in the New York market between 9:00 a.m. one day and 9:00 a.m. the following day. The intervention series are dummy variables that take the value 1 if intervention occurs between the initial and subsequent measurements of the exchange rate. These data were collected from newspaper accounts of intervention reported by *The Wall Street Journal*, *The New York Times*, or the *Financial Times* of London. Four separate intervention dummy variables represent intervention by either the Federal Reserve or the Bundesbank to increase or to depress the exchange value of the dollar. Two additional dummy variables represent coordinated intervention to increase or decrease the value of the dollar.[13] The regressions also include variables to capture monetary policy changes: the German repurchase rate as well as a dummy variable to represent days when a change occurred in the U.S. discount rate, a dummy variable to represent a day when a change occurred in the borrowed reserves target by the Federal Reserve, and a dummy variable representing days with changes in the German discount rate. Estimation is by ordinary least squares using the White (1980) correction for heteroskedasticity.[14]

The results are presented in Table 6. Interventions by the Federal Reserve have the prefix FED and interventions by the Bundesbank have the prefix BB. The intervention dummy representing days when both central banks intervene has the prefix COMB. Intervention by either central bank to weaken the dollar has the suffix W while intervention by either central bank to strengthen the dollar has the suffix S. The expected coefficient on intervention to decrease the value of the dollar by either the Federal Reserve (FED_W_t) or the Bundesbank (BB_W_t) is negative, and the expected coefficients on intervention to increase the value of the dollar (FED_S_t and BB_S_t) are positive. These coefficients (on FED_W_t, FED_S_t, BB_W_t and BB_S_t) represent the effect of intervention undertaken alone by either the Federal Reserve or the Bundesbank. The coefficient on either combined intervention dummy demonstrates that combined interventions provide a significantly more resolute signal than interventions undertaken alone. The regression controls for changes in monetary policy discussed above with the following variables: the U.S. discount rate (FED DR), the German discount rate (BB DR), the U.S. borrowings assumption (FED BR), and the German repurchase rate (RepoG).

The results support the hypothesis that intervention was perceived by the market as a signal in the first subperiod.

The results presented in Table 6 support the hypothesis that intervention was perceived by the market as a signal in the first subperiod, from the September 1985 Plaza meeting to the May 1986 Tokyo summit. No instances of combined intervention to increase the value of the dollar occurred during this period. Intervention undertaken by either central bank in isolation either had no significant effect on the deutsche mark/dollar exchange rate, or had a significant effect of the incorrect sign, as occurred in the only two cases of intervention by the Federal Reserve during this period. Intervention to decrease the value of the dollar undertaken jointly by the Federal Reserve and the Bundesbank, however, had a significant effect of the expected sign.

The second subperiod runs from the May 1986 Tokyo summit to the February 1987 Louvre meeting. During this time the Federal Reserve did not intervene jointly with the Bundesbank and intervened only twice in isolation. The estimates from this period demonstrate a significant and correctly signed effect of intervention to increase the value of the dollar by the Federal Reserve and a significant but incorrectly signed effect of intervention to decrease the value of the dollar by the Bundesbank.

Table 6
The Effects of Intervention on the Change in the DM/$ Exchange Rate
Dependent Variable: ln (s_{t+1}) − ln (s_t) where s = DM/$

Variable	Plaza to Tokyo 9/23/85–5/3/86	Tokyo to Louvre 5/6/86–2/20/87	Louvre to Crash 2/23/87–10/16/87
CONSTANT	.031	−.0039	.012
	(.032)	(.014)	(.014)
FED_W$_t$	.0070*	No observations	−.0051
	(.0007)		(.0036)
FED_S$_t$	−.0068*	.0048*	−.0037
	(.0014)	(.0011)	(.0026)
BB_W$_t$	.0013	.0063*	−.0032
	(.0013)	(.0006)	(.0028)
BB_S$_t$	.0004	−.0019	−.0024
	(.0025)	(.0019)	(.0028)
COMB_W$_t$	−.014*	No observations	.0095*
	(.003)		(.0046)
COMB_S$_t$	No observations	No observations	.0048
			(.0044)
RepoG	−.0072	.0071	−.0032
	(.0073)	(.0032)	(.0039)
BB DR	−.0027	−.0032	No observations
	(.0018)	(.0019)	
FED DR	.0037	.0008	−.0009
	(.0040)	(.0041)	(.0005)
FED BR	−.0021	No observations	−.0007
	(.0024)		(.0015)
R^2	.047	.013	.056
Durbin–Watson	1.90	2.01	2.11
Observations	154	203	166

*Significant at 95 percent level. Standard errors in parentheses.
Estimation by ordinary least squares with White (1980) correction for heteroskedasticity.

The final period begins just after the Louvre meeting in late February 1987 and ends just before the October 1987 stock market crash. A full complement of the different types of intervention occurred during this time. Not one of the coefficients is both of the right sign and statistically significant.[15]

A test of the linear combination of each central bank's intervention dummy and the combined dummy demonstrates the overall effect of each central bank's intervention on days when the other central bank also intervenes.[16] Table 7 provides summary statistics of the effect of coordinated interventions. Between the Plaza Accord and the Tokyo summit, interventions to decrease the value of the dollar by both the Federal Reserve and the Bundesbank were significant and of the right sign. In the period between the Tokyo summit and the Louvre meeting, no coordinated interventions occurred, so no observations are available. After the Louvre meeting, efforts by the Federal Reserve and the Bundesbank to increase or decrease the value of the dollar had no effect.

The results in Tables 6 and 7 tend to support the hypothesis that, at least by the end of the sample period, intervention was not perceived by market participants to be a trustworthy signal of monetary policy. The results from the first subperiod, and to a lesser extent from the second subperiod, suggest that intervention policy may have enjoyed some success initially.[17] The subsequent lack of efficacy of this policy may have been a consequence of a failure of monetary authorities to use intervention as a proxi-

mate and consistent signal of future policy. The impact of intervention on the exchange rate eroded as participants in the foreign exchange market learned of the lack of a nexus between intervention and monetary policy.

IV. Conclusions

Most empirical studies have found no evidence that sterilized intervention alone has an effect on the long-run value of the exchange rate; however, these studies frequently discuss the possibility that sterilized intervention may have significant short-run effects if it signals future monetary policy changes. This study found no evidence that reported interventions by the United States and Germany were used to signal monetary policy. Interventions did not precede monetary policy changes and periods of active intervention were not followed by monetary policy changes. Given the lack of correspondence between interventions and monetary policy, intervention could not have been an effective signal of monetary policy during the period between the Plaza Accord and the October 1987 stock market crash.

While in hindsight the data provide no evidence that interventions in foreign exchange markets were used to signal policy changes, it is possible that, at the time, market participants interpreted interventions as signals of future policy. If so, significant movements in the exchange rate would be expected at the time of interventions. Central banks actively intervened in foreign exchange markets after the Plaza Accord. Evidence suggests that combined interventions to increase the value of the dollar during this period did result in a significant decline in the deutsche mark/dollar exchange rate. As it became apparent that intervention was not signalling monetary policy changes, market participants apparently stopped interpreting intervention as a signal. Consistent with that hypothesis, no evidence was found that announcements of intervention had a significant effect after the Tokyo or Louvre meetings.

The results reported in this article do not preclude intervention as a signal of monetary policy; however, to be an effective signal requires a greater nexus between intervention and monetary policy than occurred between the Plaza meeting and the stock market crash. When joint intervention was perceived as a signal immediately after the Plaza Accord, intervention caused the dollar to depreciate, but this effect attenuated as investors perceived no change in monetary policy in the United States and Germany. Intervention could have a significant signalling effect in the future if it indicated a willingness of central banks to alter domestic monetary policy to achieve exchange rate goals. During the period under consideration, however, the evidence on portfolio effects examined by other researchers, and the evidence on signalling examined here, seem to suggest that motives of central banks may have been more political than economic in nature.

Table 7
Test of the Effects of Intervention on the DM/$ Exchange Rate
Dependent Variable: $\ln(s_{t+1}) - \ln(s_t)$ where s = DM/$

Variable	Plaza to Tokyo 9/23/85–5/3/86	Tokyo to Louvre 5/6/86–2/20/87	Louvre to Crash 2/23/87–10/16/87
$FED\_W_t + COMB\_W_t$	−.0071* (.0031)	No observations	.0044 (.0030)
$FED\_S_t + COMB\_S_t$	No observations	No observations	.0011 (.0035)
$BB\_W_t + COMB\_W_t$	−.013* (.003)	No observations	.0063 (.0063)
$BB\_S_t + COMB\_S_t$	No observations	No observations	.0025 (.0033)

*Significant at 95 percent level. Standard errors in parentheses.

[1] The nominal effective exchange rates referred to here are taken from *World Financial Markets*, published by Morgan Guaranty Trust Company.

[2] The G-5 consists of the United States, West Germany, and Japan, which constitute the G-3, along with the United Kingdom and France.

[3] Some controversy exists over whether the path taken by the dollar after the Plaza Accord was merely an extension of its depreciation during the first part of 1985.

[4] In contrast, a change in monetary policy through an open market operation would involve trades of securities for money denominated in the same currency.

[5] Some of the research that demonstrates the lack of a portfolio-balance effect includes Frankel (1982), Rogoff (1984), Lewis (1988), Engel and Rodrigues (1989), and Dominguez and Frankel (1990).

[6] U. S. interventions can be conducted by the Federal Reserve as an agent for the Treasury, or for the Federal Reserve's own account. For expositional ease we will refer to all U.S. interventions as being Federal Reserve interventions.

[7] Universal banks in Germany have much broader powers than American banks. Universal banks include private commercial banks, savings banks, and credit associations and all have access to discount loans. The specialized banks such as mortgage banks and investment companies cannot borrow from the discount window but do have access to Lombard lending, described later in this section.

[8] While the relevance of intervention cannot be addressed with the data presented here, the regression results in the next section provide insight to the combined effectiveness and relevance of intervention.

[9] A more general form of the interest parity relationship would allow for the existence of a risk premium term. Empirical attempts to model the risk premium, however, have been largely unsuccessful. This lack of success is closely tied to the inability to find a significant portfolio-balance channel for intervention, since if sterilized intervention operates through this channel it must be through a predictable effect on the risk premium term.

[10] The expression in equation 2 is an approximation of the expression in equation 1 that holds closely when interest rates or expected rates of depreciation are not too large.

[11] A fully specified model of the effect of "news" on the exchange rate has been developed by Engel and Frankel (1984), who used it to explore the effect of announcements of the money supply on interest rates and exchange rates.

[12] If intervention worked through a portfolio balance channel, and if the size of interventions did not decline significantly over time, one would not expect to see any differences in the effect of intervention on the exchange rate across subperiods.

[13] There are no instances of days when the Federal Reserve was intervening in one direction and the Bundesbank was intervening in the other direction.

[14] The assumption behind the regression is that in the absence of intervention exchange rates follow a random walk. Despite differences in stated objectives after the international summits, the intercepts which represent the time trend of the exchange rate are not significantly different across time periods.

[15] None of the monetary variables enter the regression with the right sign and statistically differ from zero in any of the time periods. Models that control more completely for expectation effects do find significant effects of monetary policy changes on exchange rates. For example, see Brown (1981) and Batten and Thorton (1984) for studies that find significant effects of discount rate changes when controlling for expectations.

[16] As indicated in Table 6, there are no observations of dollar-weakening intervention by the Federal Reserve or combined dollar-strengthening intervention during the second subperiod, or of combined dollar-strengthening intervention during the first subperiod.

[17] Similar results are reported by Dominguez (1990), who studied the effect of intervention on excess returns. In particular, she found significant effects immediately following the Plaza meeting but an erosion of the effect subsequently. She also found different effects for unilateral and coordinated intervention.

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