The Federal Reserve as an Informed Foreign Exchange Trader: 1973–1995*

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If official interventions convey private information useful for price discovery in foreign exchange markets, then they should have value as a forecast of near-term exchange rate movements. Using a set of standard criteria, we show that approximately 60 percent of all U.S. foreign exchange interventions between 1973 and 1995 were successful in this sense. This percentage, however, is no better than random. U.S. intervention sales and purchases of foreign exchange were incapable of forecasting dollar appreciations or depreciations. U.S. interventions, however, were associated with more moderate dollar movements in a manner consistent with leaning against the wind, but only 22 percent of all U.S. interventions conformed to this pattern. We also found that the larger the size of an intervention, the greater was its probability of success. In this context, most U.S. interventions appear to have been too small to have had a high probability of success. Other potential characteristics of intervention—notably, coordination and secrecy—did not seem to influence our success rates.

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> There is no evidence, nor does anybody here [in the FOMC] believe that there is any evidence, to confirm that sterilized intervention does anything.
>
> Alan Greenspan, *FOMC Transcripts*, October 3, 2000, p. 14

1. Introduction

In mid-1973, shortly after the onset of generalized floating, the United States started intervening in the foreign exchange market, buying or selling foreign currencies in an effort to influence dollar exchange rates. By 1995, however, the United States had all but abandoned these operations. The evidence over the intervening years suggested that intervention was more of a hindrance to good policy than a contribution. Starting in the late 1980s, Federal Open Market Committee (FOMC) participants increasingly questioned the effectiveness of intervention. They believed that if intervention were to have anything other than a fleeting, hit-or-miss effect on exchange rates, monetary policy had to support it. This stricture, however, implied that intervention did not afford the Federal Reserve an instrument with which to systematically affect exchange rates independent of monetary policy. Intervention could interfere with the FOMC's domestic policy objectives. Moreover, the impetus for U.S. intervention after 1985 came largely from the U.S. Treasury, which is primarily responsible for intervention in the United States. Despite having separate legal authority for intervention, the Federal Reserve System found that it could not easily avoid participating in Treasury-initiated operations. Under these circumstances, the FOMC feared, intervention must weaken confidence in the System's commitment to price stability, which at the time the committee was avidly attempting to strengthen (Broaddus and Goodfriend 1996, Bordo, Humpage, and Schwartz 2010b, and Goodfriend 2010).

While many other advanced countries followed suit, intervention operations never entirely ended. The Japanese Ministry of Finance, for example, undertook frequent—and at times massive—operations between 1991 and 2004 with an eye toward limiting the yen's appreciation against the dollar (Ito 2003, 2005, 2007). The United States, for its own part, has participated in two operations against Japanese yen and one against euros since the summer of 1995. The recent

global financial turmoil has encouraged a limited resurgence of intervention. Japan has again intervened, once with U.S. cooperation. The Swiss National Bank has also intervened heavily in an effort to limit the franc's appreciation against the euro and the dollar. Emerging markets, including Brazil, Chile, and Israel, have also intervened. The often heightened volatility of exchange rates since 2007 has prompted some economists to recommend the limited use of intervention (Neely 2011).

This paper reviews the U.S. experience from 1973 through 1995 in search of lessons pertinent to any modern reevaluation of intervention policy. Following Humpage (1999, 2000), we construct reasonable success criteria based on the correspondence between interventions and daily exchange rate movements. We count the number of observed successes under each criterion and assess whether that count exceeds the number that might occur randomly given the near-martingale nature of daily exchange rate changes. A high success count indicates that intervention had value as a forecast of near-term exchange rate patterns and implies that intervention conveyed information useful for price discovery. We also investigate whether various characteristics of an intervention, such as its size, frequency, or coordination, can increase its probability of success.

We find that 60 percent of all U.S. interventions between 1973 and 1995 were successful under our criteria—a percentage that is no better than random. This result occurs because U.S. purchases and sales of foreign exchange showed no systematic correspondence with dollar depreciations or appreciations, respectively. U.S. interventions, however, often did accompany same-day moderations of dollar exchange rate movements in a manner broadly consistent with leaning against the wind. While these successes were generally greater than random, they accounted for less than one-fourth of all U.S. interventions and were not universally robust across time periods and currencies. We also found that the larger the size of an intervention, the greater its probability of success. Most U.S. interventions, however, seemed small given these estimates; that is, the point estimates of their probability of success were low. Other characteristics of interventions—notably, coordination—seem to have had no apparent influence on our success rates.

This paper proceeds as follows: The next section draws a key distinction between sterilized and non-sterilized interventions and

discusses the theoretical channels through which sterilized intervention might operate. Section 3 explains our three success criteria, our data, and our counting methods. Section 4 evaluates our success counts under the assumption that successes are hypergeometric random variables. Section 5 checks the robustness of our results across various subperiods. Section 6 uses probit regressions to see if various characteristics of an intervention alter the likelihood of success. We use these estimates to show the relationship between the probability of success and the size of an intervention. Section 7 concludes with some discussion of our results and a few comparisons to earlier work.

2. Background

Except for the instruments involved, the mechanics of an intervention are similar to those of an open-market operation, and like an open-market operation, foreign exchange interventions have the potential to alter bank reserves. The Federal Reserve—like most large central banks—routinely sterilizes the impact of all U.S. foreign exchange operations on the monetary base (Neely 2001, Lecourt and Raymond 2006). Sterilization prevents foreign exchange transactions from interfering with the domestic objectives of monetary policy.

In contrast to the sterilized variety, non-sterilized intervention, which alters the monetary base, is essentially equivalent to introducing an exchange rate target into a central bank's reaction function. While presenting the central bank with an additional policy target, non-sterilized intervention fails to offer an additional independent instrument with which to attain that target. If an undesirable movement in the exchange rate should stem from a domestic monetary shock, then counteracting it through purchases of foreign exchange is wholly redundant to doing so through traditional open-market operations (see Bonser-Neal, Roley, and Sellon 1998, Humpage 1999).[1] On the other hand, if the initial, underlying shock to the exchange rate is something other than domestic and monetary in nature, then

[1]If a country is in a liquidity trap and long-term domestic government securities—the traditional vehicles of quantitative easing—are perfect substitutes for base or in short supply, then conducting open-market operations through foreign exchange may be advisable (see McCallum 2003).

attempting to achieve an exchange rate objective through either non-sterilized intervention or traditional open-market operations can interfere with the attainment of a central bank's domestic policy goals. If, for example, the dollar depreciates vis-à-vis a foreign currency because the foreign central bank tightens its monetary policy, then conducting non-sterilized intervention to stabilize the dollar can lower inflation below the Federal Reserve's desired level.

Sterilized intervention is useful to policymakers only to the extent that it provides a mechanism for systematically affecting exchange rates independent of their domestic monetary policy objectives. Theoretically, sterilized intervention might influence exchange rates through a portfolio-balance channel, an inventory-adjustment channel, an expectations channel, or a coordination mechanism.[2]

A portfolio-balance channel should offer central banks a way to routinely affect exchange rates without interfering with their domestic monetary policy objectives. Sterilized intervention has no effect on the monetary base, but it alters the currency composition of publicly held government securities. Specifically, the act of sterilizing an intervention increases outstanding debt denominated in the currency that central banks are selling relative to debt denominated in the currency that central banks are buying. If risk-averse asset holders view these securities as imperfect substitutes, they will hold the relatively more abundant asset in their portfolio only if the expected rate of return on this asset compensates them for the perceived risks of doing so.[3] Their initial reluctance to hold the relatively more abundant security forces a spot depreciation of the currency that central banks are selling relative to the currency that they are buying. The spot depreciation relative to the exchange rate's longer-term expected value then raises the anticipated rate of return on the now more-abundant securities and compensates asset holders for the perceived increase in risk.[4] Unfortunately, most empirical

[2]Edison (1993), Alkeminders (1995), Baillie, Humpage, and Osterberg (2000), and Sarno and Taylor (2001) provide excellent surveys of intervention. Neely (2005) also touches on some econometric issues.

[3]The portfolio-balance mechanism also assumes that no restrictions exist on cross-border financial flows and that Ricardian equivalence does not hold.

[4]Most models assume that relative changes in the stock of securities leave interest rates unaffected because monetary policy determines interest rates. This need not be the case.

studies do not find that intervention affects exchange rates through a portfolio-balance mechanism (Edison 1993). Typically, the relevant coefficients in these studies are either statistically or quantitatively insignificant, or unstable across time periods and currencies. A notable exception is Dominguez and Frankel (1993a), who find support for a portfolio-balance channel. In general, central banks put little stock in this mechanism (Neely 2007).

A variation of the standard portfolio-balance channel, the inventory-adjustment mechanism, describes how intervention might affect exchange rates in the very short run (Evans and Lyons 2001, 2005, Lyons 2001). These models focus on the role of foreign exchange dealers, who, as market makers, stand ready to buy and sell foreign exchange. These same dealers typically do not hold sizable open positions in a foreign currency, especially overnight (Cheung and Chinn 2001). They will try to distribute their unwanted currency holdings among other dealers and eventually among their commercial customers. Since different currencies are not perfect substitutes in the dealers' portfolios, this inventory-adjustment process resembles a portfolio-balance-like mechanism at the micro level. Evans and Lyons (2001, 2005) claim evidence of both temporary—dealer-to-dealer inventory reshuffling—and permanent—dealer-to-customer—portfolio-balance effects. The permanent component of this model, however, is at odds with the macro literature.

Alternatively, sterilized intervention might exert some influence over foreign exchange rates by affecting market expectations about future exchange rate changes. Unlike the portfolio-balance mechanism, an expectations channel does not alter the fundamental determinants of exchange rates but changes perceptions of those fundamentals. This may quickly shift exchange rates to an alternative path but one that is still consistent with those unchanged fundamentals.

For the expectations channel to work, information must be costly and asymmetrically distributed, and monetary authorities must have private information about exchange rates that they can convey to the market through their interventions (Baillie, Humpage, and Osterberg 2000). Survey evidence does suggest that information is asymmetrically distributed (Cheung and Chinn 2001). Large foreign exchange traders have better information than smaller traders and transfer that information through their trades. Any traders—

including monetary authorities—that others suspect of having superior information could affect prices, if market participants observed their trades.

Should we expect central banks to routinely possess a significant informational advantage over private market participants? Mussa (1981) initially suggested that a central bank might signal unanticipated changes in monetary policy through its interventions. This signal would have credence because the monetary authority will incur a capital loss on its foreign exchange position if it fails to carry through with its policy signal. Because of this condition, the signaling channel does not offer monetary authorities a mechanism through which they can routinely affect exchange rates independent of their monetary policies.

Monetary authorities, however, often claim to intervene when they view current exchange rates as being inconsistent with market fundamentals, implying that they have an information advantage beyond prospective changes in monetary policy. Central banks have large staffs that gather and analyze data, and they maintain ongoing informational relationships with major banks. Through their frequent contacts with market participants, central banks can aggregate the private information of individual traders and disseminate this information through intervention (Popper and Montgomery 2001). If monetary authorities routinely have better broad-based information than other market participants, then their interventions should accurately predict near-term exchange rate movements.

In extreme cases of information imperfections, when a substantial portion of market participants base their trades on extrapolations of past exchange rate movements, exchange rates might remain misaligned, even if more-informed traders feel that current exchange rates are inappropriate. In the presence of strong bandwagon effects or collective-action problems, informed traders may have recently lost money and withdrawn temporarily from the market, causing the misalignment to persist. In such cases, sterilized intervention might offer a coordinating signal to those traders that react to fundamentals (Sarno and Taylor 2001, Reitz and Taylor 2008). This coordination channel does not require that a central bank necessarily have better information than the market. The signal bolsters traders' confidence about their own expectations and encourages them to take positions. It does seem to require, however, that monetary

authorities lack credibility. A credible central bank could simply announce that the exchange rate is misaligned (Reitz and Taylor 2008).

In the next section, we test whether U.S. interventions had value as a forecast of subsequent exchange rate movements. As such, our tests seem consistent with an expectations channel or, possibly, a coordination mechanism.

3. Success Counts

We evaluate the success of U.S. foreign exchange operations using two specific criteria and a general criterion that incorporates the first two. In all of the definitions that follow, I_t designates U.S. intervention on day t, with positive (negative) values being sales (purchases) of foreign exchange. S_t is the opening (9:00 a.m.) spot bid for foreign exchange in the New York market on day t measured in foreign currency units per U.S. dollar, and $\Delta S_t = S_{t+1} - S_t$. The change in the exchange rate from the opening on day t to the opening on day $t+1$ brackets U.S. interventions on day t.[5] The target exchange rate is either German marks per dollar or Japanese yen per dollar, and I_t consists only of the corresponding intervention, that is, dollars against German marks or dollars against Japanese yen.

Our first binomial success criterion (SC_1) counts an official U.S. sale or purchase of foreign exchange on a particular day as a success ($\mathrm{SC}_1 = 1$) if the dollar appreciates or depreciates, as the case may be, over that same day:

$$\mathrm{SC}_1 = \begin{cases} 1 & \begin{cases} \text{if } I_t > 0, \text{ and } \Delta S_t > 0, \text{ or} \\ \text{if } I_t < 0, \text{ and } \Delta S_t < 0; \end{cases} \\ 0 & \text{otherwise.} \end{cases} \tag{1}$$

Our second success criterion (SC_2) scores an intervention as a success ($\mathrm{SC}_2 = 1$) if the United States sells foreign exchange and the dollar continues to depreciate but does so by less than over the previous day. Likewise, this criterion counts intervention as a success

[5]The United States conducts most U.S. interventions, by far, in the New York market but has on occasion placed orders through correspondents in both the European and Far Eastern markets. We cannot isolate these transactions.

if the United States buys foreign exchange and the dollar continues to appreciate but does so by less than over the previous day (for completeness, we include $\Delta S_t = 0$ in this criterion):

$$\mathrm{SC}_2 = \begin{cases} 1 & \begin{cases} \text{if } I_t > 0, \text{ and } \Delta S_{t-1} < 0, \text{ and } \Delta S_t \leq 0, \text{ and} \\ \quad \Delta S_t > \Delta S_{t-1}, \text{ or} \\ \text{if } I_t < 0, \text{ and } \Delta S_{t-1} > 0, \text{ and } \Delta S_t \geq 0, \text{ and } \Delta S_t < \Delta S_{t-1}; \end{cases} \\ 0 & \text{otherwise.} \end{cases} \tag{2}$$

Our general success criterion (SC_3) incorporates SC_1 and SC_2. Accordingly, an intervention sale of foreign exchange on a particular day is successful ($\mathrm{SC}_3 = 1$) if the dollar appreciates or if it depreciates by less than on the previous day. A corresponding rule holds for dollar purchases of foreign exchange:

$$\mathrm{SC}_3 = \begin{cases} 1 & \begin{cases} \text{if } I_t > 0, \text{ and } \Delta S_t > 0, \text{ or } \Delta S_t > \Delta S_{t-1} \text{ or} \\ \text{if } I_t < 0, \text{ and } \Delta S_t < 0, \text{ or } \Delta S_t < \Delta S_{t-1}; \end{cases} \\ 0 & \text{otherwise.} \end{cases} \tag{3}$$

We measure success over a single day, which some may find unduly restrictive (Goodhart and Hesse 1993, Fatum and Hutchison 2002). Despite the narrow window, the chance that we might fail to count an intervention as successful because the appropriate exchange rate movement occurred beyond the opening on day $t + 1$ seems remote. Chang and Taylor (1998), Chueng and Chinn (2001), and Dominguez (2003), among others, suggest that exchange markets begin to respond to intervention within minutes or hours, not days. Likewise, a majority of central bank officials in Neely's (2001) survey contended that exchange rates reflect the full effects of intervention within hours. Alternatively, by keeping the window narrow, we may count an intervention as a success even though the exchange rate change that led us to that conclusion subsequently disappears. Opening the event window beyond a single day to limit this problem, however, quickly causes overlap among interventions, making inferences about the likelihood of an intervention's success impossible.

We assume, as in Dominguez (2003, p. 34), that U.S. monetary authorities base a decision to intervene on day t only on past

information about exchange rates. We believe this to be an accurate characterization of how U.S. policymakers generally reach their decision to intervene, although the Desk may sometimes adjust the amount of an intervention in response to market reactions (Baillie and Osterberg 1997, Neely 2001). If exchange rate changes and interventions are jointly determined on day t, our counts could contain a bias (Neely 2005).

Although we do not model a specific transmission mechanism for intervention, we assume that intervention operates through an expectations channel. We are testing to see if U.S. monetary authorities have an informational advantage that they impart to the market through their interventions (à la Popper and Montgomery 2001). If central bank intervention does indeed impart new information to the market, private traders will immediately incorporate it into their exchange rate quotes. This information may be positive; that is, the market may interpret the intervention in the manner that the central bank intends. Alternatively, this information may be negative; that is, the market may react to an intervention in the opposite manner than the central bank desires. Our tests look to uncover this.

4. Evaluation

Following Henriksson and Merton (1981) and Merton (1981), we evaluate our success counts under the assumption that the number of successes is a hypergeometric random variable. The hypergeometric distribution seems appropriate because it does not require individual interventions to be independent events and does not depend on a presumed probability of an individual success. To apply the Henriksson and Merton methodology, we must consider intervention sales and purchases of foreign exchange separately.

Our null hypothesis compares the actual and the expected success counts. We reject the null and conclude that intervention has positive forecast value if the success count exceeds the expected number by two standard deviations. We reject the null and conclude that intervention has negative forecast value if the actual number of successes lies below the expected number by more than two standard deviations. If we cannot reject the null hypothesis, we conclude that the number of successes is not different than a number that could

randomly occur given the near-martingale nature of daily exchange rate changes.

This approach also assumes that intervention does not change fundamental macroeconomic determinants of exchange rates. This supposition seems appropriate given that the Federal Reserve routinely sterilizes all U.S. interventions and given the lack of evidence that sterilized intervention works through a portfolio-balance mechanism. The failure of this assumption to hold would bias our results toward finding a high number of successes in any sample.

Table 1 presents our results for the entire sample period, March 2, 1973 through March 19, 1997.[6] During these 6,274 business days, the United States intervened on 971 days against German marks and on 243 days against Japanese yen.[7] The first intervention against German marks took place on July 10, 1973, and the first intervention against Japanese yen followed on January 24, 1974. The United States intervened against German marks roughly four times as often as it did against Japanese yen. Roughly 60 percent of U.S. interventions against Japanese yen involved purchases of yen, suggesting that the United States often thought that the market overpriced the dollar. Interventions against the German mark were more evenly distributed between purchases and sales of marks, with only a slight bias toward mark purchases. (See, however, the discussion of pre-1980 interventions in section 5.)

The first column in table 1 lists the success criteria for the German marks (top section) and Japanese yen (bottom section). The second column shows official U.S. intervention purchases and sales. Between March 2, 1973 and March 19, 1997, for example, the United States sold German marks on 469 days and bought German marks on 502 days. The next two columns of data show intervention successes. Of the 469 U.S. sales of German marks, 136, or 29 percent,

[6]The United States did not abruptly end its intervention on March 19, 1997. U.S. interventions began to taper off in the early 1990s. After August 1995, the United States intervened against Japanese yen on June 17, 1998; against euros on September 22, 2000; and again against Japanese yen on March 18, 2011. These last three interventions are the only instances of U.S. intervention during the floating exchange rate era not included in our analysis. Our exchange rate data, which ends on March 19, 1997, determined our sample.

[7]The United States intervened against some other European currencies during the 1970s and early 1980s, but data on these currencies are not available.

Table 1. Success Counts for U.S. Intervention: March 2, 1973 to March 19, 1997

Opening Bid Quotes	Total #	Intervention Successes #	Intervention Successes percent	Virtual Successes #	Virtual Successes percent	Expected Successes #	Standard Deviation #
German Marks							
Observations:	6,274						
Criterion SC_1							
Sell Marks	469	136	29.0	2,951	47.0	220.6	8
Buy Marks	502	192	38.2	3,007	47.9	240.6	9
Total	971	328	33.8				
Criterion SC_2							
Sell Marks	469	117	24.9	820	13.1	61.30	4
Buy Marks	502	110	21.9	807	12.9	64.57	4
Total	971	227	23.4				
Criterion SC_3							
Sell Marks	469	253	53.9	3,771	60.1	282	12
Buy Marks	502	302	60.2	3,814	60.8	305	13
Total	971	555	57.2				

(continued)

Table 1. (Continued)

Opening Bid Quotes	Total #	Intervention Successes #	Intervention Successes percent	Virtual Successes #	Virtual Successes percent	Expected Successes #	Standard Deviation #
Japanese Yen							
Observations:	6,274						
Criterion SC_1							
Sell Yen	94	47	50.0	3,000	47.8	45	5
Buy Yen	149	63	42.3	2,836	45.2	67	5
Total	243	110	45.3				
Criterion SC_2							
Sell Yen	94	19	20.2	740	11.8	11	1
Buy Yen	149	28	18.8	829	13.2	20	2
Total	243	47	19.3				
Criterion SC_3							
Sell Yen	94	66	70.2	3,740	59.6	56	6
Buy Yen	149	91	61.1	3,665	58.4	87	7
Total	243	157	65.0				

were successful under criterion SC_1; that is, each of these 136 interventions was associated with a same-day dollar appreciation. The next two columns show virtual successes. Virtual successes follow the respective success criteria outlined in equations (1)–(3), absent any consideration of intervention. The dollar, for example, appreciated against the German mark—whether or not the United States intervened against marks—on 2,951, or 47 percent, of the 6,274 business days in our sample.

The final two columns in table 1 refer to the hypergeometric distribution. If successes are hypergeometric random variables, then in a sample of 6,274 observations with a virtual success rate of 47 percent, we would expect to observe 221 successes in 469 interventions, purely by chance. The observed number of successes, 136, falls more than two standard deviations below the expected value, implying that the United States had negative forecast value. This value is so low that market participants, who knew when the United States intervened, could have bet against the United States—bought German marks on day t—and made money on average. From an expectations-channel perspective, a U.S. sale of German marks signaled that the dollar would depreciate over the same day as the intervention. Similar results hold for purchases of German marks, implying that the United States had negative forecast value in this case too. The corresponding success counts for U.S. official interventions against Japanese yen, however, were no different than random.

In contrast to the results under success criterion SC_1, the success counts under SC_2, for both U.S. interventions against German marks and Japanese yen, are more than two standard deviations *above* their expected values, indicating that U.S. interventions had positive forecast value with respect to criterion SC_2. When the dollar is depreciating and the United States sells foreign exchange, it is a good bet that the dollar will continue to depreciate but will do so by less than on the day prior to the intervention. Likewise, when the dollar is appreciating and the United States buys foreign exchange, it is a good bet that the dollar will continue to appreciate but will do so by less than on the day prior to the intervention.

While the successes under criterion SC_2 clearly exceed the expected number, the overall frequency of this type of success is fairly low. Only 23 percent of all U.S. interventions against German

marks and 19 percent of all U.S. interventions against Japanese yen were successful under the SC_2 criterion.

The final, general success criterion, SC_3, combines SC_1 and SC_2. Generally, we expect that approximately 60 percent of all interventions will be successful under at least one of our success criteria purely by chance. (See the virtual counts under SC_3 in table 1.) The total number of actual successes under SC_3 is—in all but one case—no better than random. The exception is the total for U.S. sales of German marks, which falls more than two standard deviations below the expected number.

5. Robustness

We repeated our counting analysis for various subperiods as a robustness check. We start by dividing the sample into two parts: The first broad subperiod runs from March 2, 1973, when generalized floating was just beginning, through April 17, 1981, when the Reagan administration announced its minimalist intervention strategy. The second broad subperiod extends from April 20, 1981, the start of the minimalist period, through March 19, 1997, the end of our sample period. Next, we divided each of these two subperiods further.

Table 2 summarizes our results for the various subperiods, with N and P indicating that the number of actual successes for a specific criterion was, respectively, two standard deviations below or above the expected number and suggesting, respectively, that intervention had negative or positive forecast value for a designated criterion.[8] An R in table 2 indicates that the observed number of successes was no different than the number that we expect purely by chance.

The table cautions that overall conclusions about intervention are not necessarily robust across time periods or across currencies within any time period. Nevertheless, some relatively persistent patterns stand out: First, U.S. intervention in German marks prior to April 17, 1981 universally had negative forecast value (N) with respect to criterion SC_1 and universally had positive forecast value

[8] An appendix in the working paper version of this paper contains the detailed data that we used to construct table 2.

Table 2. A Summary of the Success Counts across Time Periods

	U.S. Intervention against German Marks								U.S. Intervention against Japanese Yen							
Success Criterion: *Sell/Buy Foreign Exchange:*	*Sell*	*Buy*	SC_1 *Sell*	SC_1 *Buy*	SC_2 *Sell*	SC_2 *Buy*	SC_3 *Sell*	SC_3 *Buy*	*Sell*	*Buy*	SC_1 *Sell*	SC_1 *Buy*	SC_2 *Sell*	SC_2 *Buy*	SC_3 *Sell*	SC_3 *Buy*
Mar. 2, 1973–Mar. 19, 1997:	469	502	**N**	**N**	**P**	**P**	**N**	**R**	94	149	**R**	**R**	**P**	**P**	**R**	**R**
Mar. 2, 1973–Apr. 17, 1981:	391	348	**N**	**N**	**P**	**P**	**N**	**R**	11	31	**R**	**R**	**R**	**P**	**R**	**R**
Mar. 2, 1973–Sep. 14, 1977:	161	176	**N**	**N**	**P**	**P**	**N**	**R**	0	2	(none)	**R**	(none)	**R**	(none)	**R**
Sep. 15, 1977–Oct. 5, 1979:	175	58	**N**	**N**	**P**	**P**	**R**	**N**	10	19	**R**	**N**	**R**	**P**	**R**	**R**
Oct. 8, 1979–Apr. 17, 1981:	55	114	**N**	**N**	**P**	**P**	**R**	**R**	1	10	**R**	**R**	**R**	**R**	**R**	**R**
Apr. 20, 1981–Mar. 19, 1997:	78	154	**R**	**R**	**P**	**P**	**R**	**R**	83	118	**R**	**R**	**P**	**P**	**R**	**R**
Apr. 20, 1981–Mar. 29, 1985:	1	24	**N**	**N**	**R**	**P**	**N**	**R**	0	11	(none)	**R**	(none)	**P**	(none)	**R**
Apr. 1, 1985–Apr. 29, 1988:	33	19	**R**	**R**	**P**	**P**	**R**	**R**	52	20	**R**	**R**	**P**	**R**	**R**	**R**
May 2, 1988–Mar. 19, 1997:	44	111	**R**	**R**	**R**	**R**	**R**	**R**	31	87	**R**	**R**	**P**	**P**	**R**	**R**

Key:
N = Negative forecast value. Observed number of successes falls below the expected number of successes by more than two standard deviations.
P = Positive forecast value. Observed number of successes exceeds the expected number of successes by more than two standard deviations.
R = Random. Observed number of successes falls within two standard deviations of the expected number of successes.

(P) with respect to criterion SC_2. Often during this time period—certainly before September 15, 1977—the United States feared that private traders might interpret an intervention as a sign that the dollar was fundamentally weak and that market participants might bet against the System's interventions.[9] Our results validate this concern. To avoid such an adverse response, the United States typically transacted in small amounts through the agency of a commercial bank in the broker's market. Operating in this manner kept the System anonymous. In addition, Greene (1984, p. 127), who once managed U.S. foreign exchange operations, suggests that over this time period, U.S. policymakers usually only hoped to smooth exchange rate movements; that is, the United States usually cared more about results under SC_2 than under SC_1. Moreover, despite what the numbers of purchases and sales might suggest, the United States typically sought only to moderate dollar depreciations—not appreciations. The United States, however, often financed its foreign exchange sales through swap drawings and had to repurchase the foreign exchange to repay the swaps fairly quickly. These repurchases may have had no exchange rate objective other than to avoid creating market disorder in the process.

Second, U.S. interventions against Japanese yen prior to the Plaza Accord—with few exceptions—seem unsuccessful under each of our three criteria. Prior to the Plaza Accord, however, the United States rarely intervened against Japanese yen. With so few observations, drawing firm conclusions about the success of U.S. interventions against Japanese yen may be risky. (A similar caveat applies to the interventions against German marks over the April 20, 1981 through March 29, 1985 minimalist period.)

Third, the large U.S. interventions associated with the Plaza and Louvre Accords (April 1, 1985 through April 29, 1988) and with the U.S. Treasury-led interventions of the very late 1980s and early 1990s had overall success counts that were not obviously different than previous episodes. Economists have often regarded the interventions following the Plaza and Louvre Accords as highly successful. The failure to find positive forecast value under SC_1 suggests that U.S. interventions could not have maintained a target-zone arrangement

[9]Bordo, Humpage, and Schwartz (2010a) provide a detailed discussion of intervention prior to 1981.

once the dollar reached a band. We do, however, find evidence of positive forecast value under SC_2 for U.S. purchases and sales of German marks during the Plaza and Louvre period, for U.S. sales of Japanese yen during both of the final two subperiods, and for U.S. purchases of yen in the last period.

Fourth, U.S. interventions lack positive forecast value under success criterion SC_3 during every subperiod portrayed in table 2. Our overall finding that fewer than 60 percent of U.S. interventions had positive forecast value seems consistent across time periods and currencies.

6. Conditional Probability

Tables 1 and 2 describe the unconditional probabilities of success under our three criteria. U.S. monetary authorities, however, conceivably could have increased their odds of success by altering the way in which they undertook an intervention. Tables 3 through 6 present a series of probit regressions that attempt to describe how various conditioning variables affected the outcome. Tables 3 and 5 show estimates for only U.S. interventions against German marks and Japanese yen, respectively, over our entire sample period—March 2, 1973 through March 19, 1997. Tables 4 and 6 consider shorter sample periods, which allow us to include, respectively, published data on German and Japanese intervention in our probit regressions. Data on German intervention against U.S. dollars are publicly available between January 1, 1976 and December 29, 1995, and data on Japanese intervention against U.S. dollars are publicly available between January 1, 1991 and March 19, 1997. The dependent variable in all cases is our general success criterion, SC_3, since we do not know whether the United States was pursuing criterion SC_1 or SC_2 at any particular time. The independent variables in the various probit regressions appear in the first columns of tables 3 through 6. We continue to assume that intervention works through an expectations channel and choose variables that might influence how U.S. monetary authorities affect market expectations, such as the consecutive number of interventions or the lapse of time between operations. We drop non-intervention days from the sample and run the probit regressions only over observations containing intervention.

Table 3. Determinants of the Likelihood of Success: U.S. Intervention against German Marks

Independent Variables **Estimation Period: Mar. 2, 1973–Mar. 19, 1997**	**Constant** *t-statistic:*	**Coefficient** *t-statistic:*	**Log Likelihood**	**Likelihood Ratio Test**
Constant Only	0.180 *4.46*		−663.1	
Amount of U.S. Intervention (abs. value)	0.107 *2.18*	0.001 *2.60*	−659.6	6.99
Buy Foreign Exchange (dummy)	0.099 *1.71*	0.158 *1.96*	−661.2	3.83
Lagged Same-Type Intervention (dummy)	0.018 *0.32*	0.329 *4.05*	−654.8	16.44
Lagged Different-Type Intervention (dummy)	0.204 *4.90*	−0.47 *−2.49*	−659.92	6.29
Consecutive Interventions (days)	0.116 *2.05*	0.02 *1.62*	−661.74	2.65
Elapse Since Last Intervention (days)	0.165 *3.94*	0.003 *1.43*	−661.86	2.41
Compatible Change in Federal Funds or Discount Rate (dummy)	0.183 *4.50*	−0.436 *−0.77*	−662.8	0.60
	5 percent p-value	*10 percent p-value*		
Critical Chi-Square Value 1 d.f.	3.84	2.71		

Table 4. Determinants of the Likelihood of Success: U.S. and German Intervention against Marks

Independent Variables **Estimation Period: January 1, 1976–December 29, 1995**	**Constant** *t-statistic:*	**Coefficient** *t-statistic:*	**Log Likelihood**	**Likelihood Ratio Test**
Constant Only	0.160 *3.42*		−494.6	
Amount of U.S. Intervention (abs. value)	0.046 *0.77*	0.001 *3.01*	−489.9	9.43
Buy Foreign Exchange (dummy)	0.10 *1.48*	0.12 *1.32*	−493.7	1.75
Coordinated Intervention; German on t (dummy)	0.336 *5.04*	−0.353 *−3.75*	−487.5	14.12
Coordinated Intervention; German on t+1 (dummy)	0.216 *3.48*	−0.130 *−1.37*	−493.6	1.89
Total Intervention; U.S. + German at t (abs. value)	0.176 *2.95*	−0.0001 *−0.431*	−494.48	0.19
Total Intervention; U.S. + German at t+1 (abs. value)	0.167 *2.80*	0.00 *−0.17*	−494.56	0.03
Lagged Same-Type Intervention (dummy)	0.017 *0.26*	0.289 *3.08*	−489.8	9.49
Lagged Different-Type Intervention (dummy)	0.177 *3.71*	−0.50 *−1.87*	−492.8	3.57
Consecutive Interventions (days)	0.12 *1.90*	0.01 *0.87*	−494.2	0.75
Elapse since Last Intervention (days)	0.14 *2.91*	0.003 *1.47*	−493.28	2.58
Compatible Change in Federal Funds or Discount Rate (dummy)	0.163 *3.47*	−0.417 *−0.73*	−494.3	0.543

Table 5. Determinants of the Likelihood of a Success: U.S. Intervention against Japanese Yen

Independent Variables **Estimation Period: Mar. 2, 1973–Mar. 19, 1997**	**Constant** *t-statistic:*	**Coefficient** *t-statistic:*	**Log Likelihood**	**Likelihood Ratio Test**
Constant Only	0.375 *4.54*		−157.9	
Amount of U.S. Intervention (abs. value)	0.232 *2.04*	0.001 *1.79*	−156.2	3.40
Buy Foreign Exchange (dummy)	0.531 *3.90*	−0.249 *−1.45*	−156.8	2.13
Lagged Same-Type Intervention (dummy)	0.303 *2.67*	0.151 *0.92*	−157.5	0.84
Lagged Different-Type Intervention (dummy)	***not applicable***			
Consecutive Interventions (days)	0.391 *3.27*	−0.01 *−0.19*	−157.9	0.04
Elapse since Last Intervention (days)	0.347 *4.03*	0.001 *1.05*	−157.2	1.48
Compatible Change in Federal Funds or Discount Rate (dummy)	0.371 *4.489*	5.771 *0.001*	−157.5	−157.5
	5 percent p-value	*10 percent p-value*		
Critical Chi-Square Value 1 d.f.	3.84	2.71		

Table 6. Determinants of the Likelihood of a Success: U.S. and Japanese Intervention against Yen

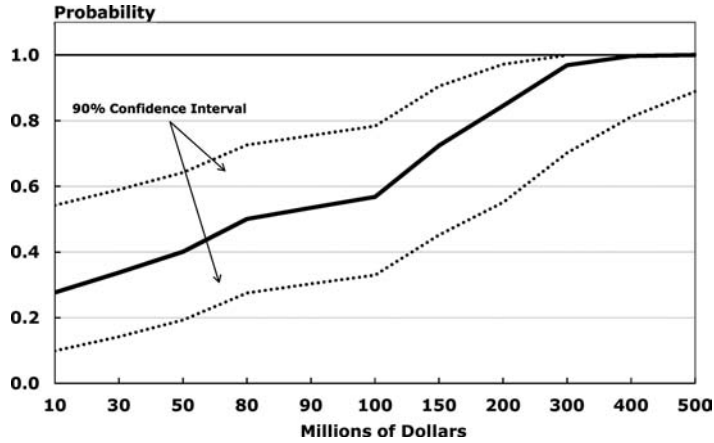
Independent Variables **Estimation Period: January 1, 1991–March 19, 1997**	**Constant** *t-statistic:*	**Coefficient** *t-statistic:*	**Log Likelihood**	**Likelihood Ratio Test**
Constant Only	0.605 *2.12*		−12.9	
Amount of U.S. Intervention (abs. value)	−0.706 *−1.11*	0.005 *2.09*	−9.6	6.58
Coordinated Intervention; Japanese on t (dummy)	−5.703 *0.00*	6.416 *0.00*	−11.5	2.73
Coordinated Intervention; Japanese on t+1 (dummy)	1.335 *2.52*	−1.221 *−1.87*	−10.9	3.92
Total Intervention with Japanese at t (abs. value)	−0.333 *−0.54*	0.001 *1.63*	−11.0	3.81
Total Intervention with Japanese at t+1 (abs. value)	0.794 *1.63*	−0.0003 *−0.48*	−12.8	0.24
Buy Foreign Exchange (dummy)	0.97 *2.75*	−1.642 *−2.14*	−10.4	5.06
Lagged Same-Type Intervention (dummy)	0.634 *2.05*	−0.203 *−0.25*	−12.9	0.06
Lagged Different-Type Intervention (dummy)	***not applicable***			
Consecutive Interventions (days)	0.837 *0.86*	−0.203 *−0.25*	−12.9	0.06
Elapse since Last Intervention (days)	0.85 *2.30*	−0.003 *−1.12*	−12.3	1.24
Compatible Change in Federal Funds or Discount Rate (dummy)	***not applicable***			

Although a few variables appear to be statistically significant in specific cases, the only variable that consistently explains the likelihood of success across all of the estimates in tables 3 through 6 is the dollar amount of a U.S. intervention. The results for those other variables that sometimes appear significant are either not robust to changes in the sample size (necessary to include foreign intervention) or across currencies, or they prove collinear with the amount of U.S. intervention.

The United States, for example, often undertook intervention in concert with the Bundesbank or the Bank of Japan. A coordination dummy is significant for German mark intervention at time t, but it lowers the likelihood of success (table 4). German intervention at t, however, appears collinear with the amount of U.S. intervention. The United States spent more on average when Germany intervened ($113.4 million) than when Germany did not enter the market ($89.1 million). At time $t + 1$, however, U.S.–Bundesbank coordination is not significant. When we add the amount of German intervention at either time t or at time $t + 1$ to U.S. intervention at time t to construct a new variable consisting of the total amount of intervention (U.S. and/or German), the amount is not significant. Given the time difference between Frankfurt and New York and given the timing convention in this paper, German interventions at t and $t + 1$ overlap U.S. intervention on day t, so we should consider both measures of intervention. Similarly, the coordination dummy for Japanese intervention on day t is significant and suggests that coordinated intervention increased the likelihood of success (table 6). All but one U.S. intervention over this period, however, are coordinated with Japan on day t, so the variable adds virtually no additional information. Given the time difference between Tokyo and New York and given our timing conventions, comparing Japanese intervention at $t + 1$ with SC_3 at time t seems appropriate, but when we do so, the coefficient suggests that coordinated intervention lowers the likelihood of success. When we instead add the amount of Japanese intervention at either time t or time $t+1$ to U.S. intervention, again creating a new series of total U.S. and/or Japanese intervention, the amount is not statistically significant.

The dummy variables that consider the sign on the previous day's intervention—lagged same-type intervention and lagged different-type intervention—are both significant in the German mark case

Figure 1. The Probability of a Successful Intervention against German Marks

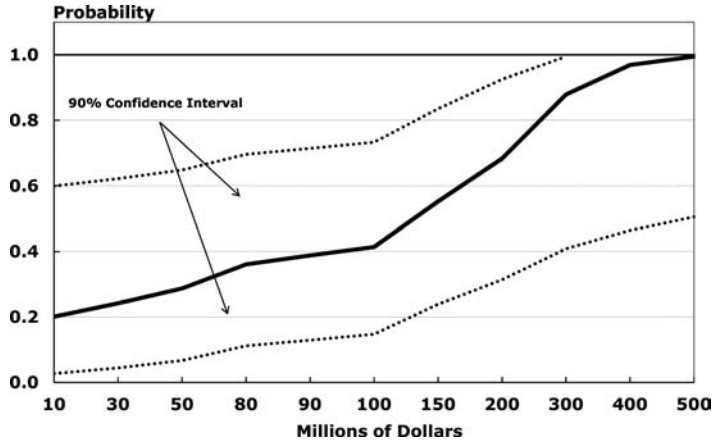


(tables 3 and 4) but not in the Japanese yen case (tables 5 and 6). For the German mark case, these variables seem collinear with the amount of U.S. intervention.

The probit regression in tables 3 and 5 suggest that the likelihood of a successful intervention under criterion SC_3 increased with the size of an intervention. Figure 1 uses the coefficient estimate from table 3 for U.S. intervention against German marks to approximate how the probability of success increased with the size of an intervention. We also include a 90 percent confidence interval around this projection. Figure 2 shows similar probability calculations for U.S. interventions against Japanese yen.

Although—as figure 1 illustrates—the probability of a successful U.S. intervention against German marks increased with the size of an intervention, most operations between March 2, 1973 and March 19, 1997 were relatively small. Our counting exercise in table 1 indicated that only 57 percent of U.S. interventions against German marks were successful under the SC_3 criterion and that the probability of a virtual success under SC_3—that is, a random success—was approximately 60 percent. Based on our estimates in figure 1, a U.S. intervention of $110 million against German marks—all else constant—had a 60 percent probability of being successful, but over the entire sample period, fewer than 25 percent of U.S. interventions against

Figure 2. The Probability of a Successful Intervention against Japanese Yen



German marks were greater than $100 million. The mean intervention in our sample was $80 million, while the median intervention was only $31 million. Only 11 percent of all U.S. interventions over this time period exceed $200 million, an amount with an estimated 85 percent probability of success, and only 5 percent exceed $300 million, an amount with an estimated 97 percent probability of success. The small size of a typical intervention may partially explain the relatively low number of observed successes relative to what one might randomly have anticipated.

A similar conclusion emerges for U.S. interventions against Japanese yen. The probability of success in figure 2 increases with the size of an intervention. Over the entire sample, the unconditional probability of success for U.S. interventions against Japanese yen under criterion SC_3 was 65 percent, somewhat higher than the probability of a virtual success at roughly 60 percent (see table 1). We find that a U.S. intervention against Japanese yen of $187 million had a 65 percent probability of success. The average U.S. intervention against Japanese yen over the sample period, however, was $131 million, and the median intervention against Japanese yen equaled only $90 million. Only 10 percent of the interventions against Japanese yen exceed $300 million, an amount with an estimated 88 percent probability of success, and only 6 percent of the interventions exceed

$400 million, an amount with an estimated 97 percent probability of success. As with intervention against German marks, the small size of a typical U.S. intervention against Japanese yen may help explain the observed low success rate.

Although the scale of U.S. interventions increased between 1973 and 1995, the interventions may not have kept pace with the rapid growth of the foreign exchange market. To see if the scale of operations mattered, we adjusted the U.S. interventions for the size of the foreign exchange market, using the growth of total U.S. assets plus liabilities from the U.S. Commerce Department's (Bureau of Economic Analysis) international investment position accounts.[10]

The resulting probit regression for U.S. intervention against German marks was

$$\begin{aligned} \mathrm{SC}_3 &= 0.112 + 0.008\ (\mathrm{ADJINT}) \\ &\quad (2.16)\quad (2.08) \qquad\qquad \mathrm{LLF} = -660.82; \mathrm{LRT} = 4.49, \end{aligned} \tag{4}$$

and that for U.S intervention against Japanese yen was

$$\begin{aligned} \mathrm{SC}_3 &= 0.312 + 0.007\ (\mathrm{ADJINT}) \\ &\quad (2.80)\quad (0.82) \qquad\qquad \mathrm{LLF} = -157.57; \mathrm{LRT} = 0.69, \end{aligned} \tag{5}$$

where SC_3 is our bivariate success criteria, and ADJINT is the absolute value of the amount of intervention against German marks or Japanese yen, as the case may be, divided by the adjustment factor for the size of the market. The adjusted amount of intervention is statistically significant in the German-mark case (equation (4)) but is not statistically significant at an acceptable level in the Japanese-yen case (equation (5)).

When we calculate probabilities of success from equation (4) for U.S. interventions against German marks, however, we find that they

[10]The international investment position data are annual, end-of-year stocks beginning in 1976. We interpolated the change in these data at a monthly frequency and used the resulting number to deflate the corresponding daily intervention data. We take this as a rough comparison of the interventions with the flow of dollars through the foreign exchange market. Prior to 1977, we use the 1976 to 1977 adjustment factor to scale the data.

are not substantially different than those calculated from the corresponding equation in table 3 for the unadjusted intervention data. Whereas the estimated probabilities of success for an average-sized ($80 million) and a median-sized ($31 million) U.S. intervention against German marks—as reported in figure 1—were 50 percent and 34 percent, respectively, the estimated probabilities for the average value and median value of ADJINT were 50 percent and 36 percent, respectively. Likewise, the estimated probability of success associated with a $300 million U.S. intervention against German marks was almost 97 percent, and the estimated probability for a similarly scaled ADJINT was 98 percent. A similarly close correspondence between the scaled and unscaled intervention amounts persisted across all values shown in figure 1. The adjustment did not alter the probabilities of success.

7. Conclusion and Discussion

Between the inception of generalized floating in 1973 and the FOMC's abandonment of its active intervention policy in 1995, approximately 60 percent of all official U.S. transactions in the foreign exchange market were associated with a same-day exchange rate movement that U.S. authorities could have easily deemed a success. Given the near-martingale nature of exchange rate changes, this percentage is no different than what we expect to find purely by chance. Overall, U.S. intervention lacked value as a forecast of near-term exchange rate movements, indicating that U.S. monetary authorities did not routinely possess private information useful for price discovery in the foreign exchange market.

This general result, however, combines two very different outcomes: U.S. intervention sales and purchases of foreign exchange were generally incapable of forecasting dollar appreciations or depreciations, respectively. This negative result is robust across all time periods and both of the currencies that we considered, and prior to 1981, private market participants could have profitably bet against U.S. interventions in German marks. In sharp contrast, we do find that U.S. intervention was associated with more moderate movements in the dollar in a manner consistent with leaning against the wind. A private trader observing U.S. intervention usually could have predicted this outcome. Neely and Weller (1997) and LeBaron

(1999) cite leaning-against-the-wind intervention strategies as a reason for their finding that intervention improves the profitability of technical trading rules. That said, only about 22 percent of all U.S. interventions conformed to this pattern, and the result—while strong—is not universal across every time period and currency.

Our findings do not seem to reflect a purely U.S. phenomenon. Using like techniques, Chaboud and Humpage (2005) and Humpage and Ragnartz (2005) found similar results for Japanese interventions between 1991 and 2004 and Swedish interventions between 1993 and 2002, respectively.

While our criteria are consistent with the notion of a successful intervention, they are not the only conceivable criteria. Greene (1984, p. 129) suggests some other criteria—for example, wide bid-ask spreads—that U.S. monetary authorities have viewed as consistent with market disorder. Moreover, intervention, or even the threat of intervention, can affect market expectations and actions in ways that such criteria cannot easily capture. Galati, Melick, and Micu (2005), for example, investigate how the higher moments of market expectations, which they derive from the distribution of option prices, respond to intervention.

We also found some evidence that the probability of a successful intervention—measured broadly (SC_3)—increased with the amount of an intervention. All else constant, large U.S. interventions may have conveyed private information better than small transactions. Our probability point estimates suggest, however, that most U.S. interventions—roughly three-fourths—were too small to have an estimated probability of success greater than random—approximately 60 percent. If U.S. monetary authorities had private information useful to price discovery, they did not convey it forcefully to the market. Had the United States intervened in larger amounts between 1973 and 1995, the success score would, most likely, have been larger.

We did not find evidence that coordinated intervention increased the likelihood of success. The empirical evidence on coordination seems mixed. Humpage (1999) found that coordination increased the probability of success by roughly 20 percent during the Louvre period (1987–90). Dominguez and Frankel (1993a, 1993b) also found in favor of coordination. Humpage and Osterberg (1992), however, found that unilateral U.S. interventions were more effective

than coordinated interventions between 1983 and 1990. Chaboud and Humpage (2005) found only weak evidence that coordination increased the probability of success for Japanese interventions against dollars between 1991 and 2004. The importance of coordination may be situational.

Also controversial is the relative importance of secrecy to an intervention's effectiveness. Given that intervention often operates through an expectations channel, secrecy may seem counterproductive, but Bhattacharya and Weller (1997) and Vitale (1999) present theoretical models in which secrecy contributes to an intervention's success. Dominguez and Frankel (1993a), Hung (1997), Chiu (2003), and Beine and Bernal (2007) also discuss various reasons for maintaining secrecy. Prior to the late 1970s, the System usually operated covertly. Thereafter, the System usually operated openly. In comparing our results across time periods consisting of various degrees of secrecy, we find no reason to believe that secrecy is important for success.

Overall, our analysis of the U.S. experience with sterilized foreign exchange intervention between 1973 and 1997 cautions against a return to an active intervention policy. Our results suggest that U.S. policymakers did not routinely have private information useful for price discovery in the foreign exchange market, and if—or when—they did, they did not convey it forcefully enough. In hindsight, the scale of operations seemed small. Generally, however, sterilized intervention seemed more of a hit-or-miss phenomenon than a sure bet. Chairman Greenspan's observation, cited at the head of this paper, may have been a bit strong, but not by much.

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