working paper 09 03

A Brief Empirical History of U.S. Foreign-Exchange Intervention: 1973–1995

by Michael D. Bordo, Owen F. Humpage, and Anna J. Schwartz

FEDERAL RESERVE BANK OF CLEVELAND

Working Paper 09-03 May 2009

A Brief Empirical History of U.S. Foreign-Exchange Intervention: 1973–1995

by Michael D. Bordo, Owen F. Humpage, and Anna J. Schwartz

This paper assesses U.S. foreign-exchange intervention since the inception of generalized floating. We find that intervention was by and large ineffectual. We first identify which interventions were successful according to three criteria. Then, we test whether the number of observed successes significantly exceeds the amount that would randomly occur given the near-martingale nature of daily exchange-rate changes. Finally, we investigate whether the various characteristics of an intervention—its size, frequency, or coordination—can increase the probability of success. We find that intervention did tend to moderate same-day exchange-rate movements relative to the previous day, but this effect is not robust across subperiods or currencies and it occurs infrequently. Increasing the size of an intervention increases the probability of success, but no other variable consistently makes a difference, including coordinating interventions with other central banks.

Keywords: Foreign-exchange intervention, exchange rates, Federal Reserve

JEL classification: F3

Michael D. Bordo is at Rutgers University; Owen F. Humpage is at the Federal Reserve Bank of Cleveland, and Anna J. Schwartz is at the National Bureau of Economic Research. Comments can be sent to owen.f.humpage@clev.frb.org.

1. Introduction

Between mid-1973—shortly after the onset of generalized floating—until mid-1995, the United States often intervened in the foreign-exchange market. Intervention refers to official purchases or sales of foreign exchange undertaken to influence exchange rates. Economists persistently questioned the effectiveness of the U.S. operations, primarily because the Federal Reserve routinely sterilized the impact of these interventions on the monetary base. Over the years, the weight of evidence seems to have gone against an activist intervention policy, but it did not entirely rule out such operations. Although the United States, like most other key developed countries, currently eschews intervention, differences of opinion about the effectiveness of intervention persist.

This paper offers an assessment of U. S. intervention since the inception of generalized floating. Following Humpage (1999, 2000), we construct success criteria that allow us to assess the impact of official interventions on near-term exchange-rate movements. These criteria are frequently mentioned in official U.S. discussions of intervention. We test whether the number of observed successes using these criteria significantly exceeds the amount that would randomly occur given the near-martingale nature of daily exchange-rate changes. Finally, we investigate whether the various characteristics of an intervention—its size, frequency, or coordination—can increase the probability of its success.

We find that U.S. intervention often moderated same-day movements of dollar exchange rates relative to the previous day; that is, U.S. intervention showed some limited capacity to successfully lean against the wind. Fewer than one-fourth of all U.S. interventions, however, were successful in this respect, nor was this result universally robust across time periods and currencies. We also find that the ability of U.S. intervention to promote either dollar

appreciations or depreciations was nonexistent. The success rate of such attempts was no better than random, suggesting that intervention could not maintain an exchange-rate target. That said, the larger the size of an intervention, the greater is its probability of success, although an intervention can be inefficiently large. Other characteristics of interventions, notably coordination, have no apparent influence on success rates.

This paper proceeds as follows: The next section distinguishes between sterilized and nonsterilized 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 asks if the characteristics of an intervention—its size, frequency, or coordination—alters the probability of success. Section 7 concludes with a few comparisons to earlier work.

2. Background

In the United States the U.S. Treasury has primary responsibility for foreign-exchange intervention.[1] The Federal Reserve, however, maintains its own portfolio of foreign exchange and routinely joins with the Treasury in such operations. The Federal Reserve—like most large central banks—routinely sterilizes all U.S. foreign-exchange operations in the sense that it does not allow these transactions to interfere with the attainment of its near-term monetary-policy objectives, like its federal-funds-rate target (Neely 2001, Lecourt and Raymond 2003). Sterilization prevents foreign-exchange transactions from interfering with the domestic objectives of monetary policy. This is particularly important for countries, like the United States,

which have independent central banks, but whose fiscal authorities hold primary responsibility for intervention.

In contrast, nonsterilized intervention, which alters the monetary base, is functionally equivalent to introducing an exchange-rate target into a central bank's reaction function. Bonser-Neal et al. (1998) and Humpage (1999) suggest that central banks reap no tactical advantage with respect to an exchange-rate objective by undertaking nonsterilized intervention instead of traditional open-market operations. Moreover, under some types of economic shocks, attempting to achieve an exchange-rate objective can interfere with the attainment of a central bank's domestic policy goals.

Because sterilized intervention has no effect on the monetary base, economists have long questioned its effectiveness. Theoretically, sterilized intervention might influence exchange rates through either a portfolio-balance channel, an inventory-adjustment channel, or an expectations channel. The empirical analysis in this paper—like that in most other papers—is not a direct test of any of these mechanisms. Although the design and the results of our tests seem more consistent with an expectations channel, than a standard portfolio-balance channel, our successes could also include inventory-adjustment affects.

A portfolio-balance channel should offer central banks a way to routinely and fundamentally 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 publically held government securities. Specifically, it 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 securities in different currency denominations as imperfect substitutes, they will hold them in their portfolio only if the

expected rates of return on these assets compensate them for the perceived risks of doing so.[2] Asset holders will balk at acquiring an increasingly abundant—hence risky—security. Their behavior should force a spot depreciation of the currency that central banks are selling relative to the currency that they are buying, which then raises the expected rate of return on securities denominated in the depreciating currency. Unfortunately, empirical studies do not find that intervention affects exchange rates through a portfolio-balance mechanism (Edison 1993). Typically, in these studies, the relevant coefficients are either statistically insignificant, 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.

A variation of the standard portfolio-balance channel, the inventory-adjustment mechanism, describes how intervention might affect exchange rates in the very short run. It suggests that market makers will temporarily alter their exchange-rate quotations following large official transactions in order to adjust their portfolios and to avoid maintaining an uncovered position over long periods (Even and Lyons 2001, 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 for very long, especially overnight (Cheung and Chinn 2001). They will try to distribute their exposure among other dealers and eventually among their commercial customers. This kind of adjustment may explain the intraday evidence on intervention (see, for example, Dominguez 2003). Our results could pick up inventory-adjustment effects.

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, the 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 ultimately 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, et al. 2000). Survey evidence suggests that large foreign-exchange traders have better information than smaller traders. Large traders have a broader customer base and market network, which gives them better insight about order flow and the activities of other traders (Cheung and Chinn, 2001). They transfer that information through their trades. In markets characterized by asymmetric information, nonfundamental forces—bandwagon effects, overreaction to news, technical trading—may sometimes shape short-term exchange-rate dynamics. Any traders—including central banks—that others suspect of having superior information could affect prices, if market participants observed their trades.

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, individually informed traders may have recently lost money and withdrawn temporarily from the market, causing the misalignment to persist. Sterilized intervention—in addition to providing information about current fundamentals—might in this case help market participants to coordinate on the "correct" equilibrium (Sarno and Taylor, 2001 and Reitz and Taylor, 2008).

Intervention can be effective in such markets only if monetary authorities routinely possess a significant informational advantage over private-market participants. Mussa (1981) initially suggested that central banks might signal unanticipated changes in monetary policy through their intervention. Monetary authorities, however, often claim to intervene when they view current exchange rates as being inconsistent with market fundamentals defined more broadly than just 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 intervention should accurately predict near-term exchange-rate movements. We test for such a relationship in the next section.

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 all U.S. interventions on day t.[3] 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 (SC1) counts an official U.S. sale or purchase of foreign exchange on a particular day as a success (SC1=1) if the dollar appreciates or depreciates, as the case may be, over that same day:

$$1) \qquad SC1 = \begin{cases} 1 & \begin{cases} \text{if } I_t > 0, \text{and } \Delta S_t > 0, \text{or} \\ \text{if } I_t < 0, \text{and } \Delta S_t < 0; \end{cases} \\ 0 & \text{otherwise.} \end{cases}$$

Our second success criterion (SC2) is consistent with a leaning-against-the-wind objective. It scores an intervention as a success (SC2=1) if the United States sells foreign exchange and the dollar continues to depreciate, but does so by less than on the previous day. Likewise, this criterion counts intervention as a success if the United States buys foreign exchange and the dollar continues to appreciate, but does so by less than on the previous day.

$$2) \qquad SC2 = \begin{cases} 1 & \begin{cases} \text{if } I_t > 0, \text{and } \Delta S_{t-1} < 0, \text{and } \Delta S_t < 0, \text{and } \Delta S_t > \Delta S_t, \text{or} \\ \text{if } I_t < 0, \text{and } \Delta S_{t-1} > 0, \text{and } \Delta S_t > 0, \text{and } \Delta S_t < \Delta S_{t-1}; \end{cases} \\ 0 & \text{otherwise.} \end{cases}$$

Our general success criterion (SC3) incorporates SC1 and SC2. Accordingly, an intervention sale of foreign exchange on a particular day is successful (SC3=1) if the dollar appreciates or depreciates by less than on the previous day. A corresponding rule holds for dollar purchases of foreign exchange.

$$3) \qquad SC3 = \begin{cases} 1 & \begin{cases} \text{if } I_t > 0, \text{and } \Delta S_{t-1} > 0, \text{or } \Delta S_t > \Delta S_{t-1} \text{ or} \\ \text{if } I_t < 0, \text{and } \Delta S_{t-1} < 0, \text{or } \Delta S_t < \Delta S_{t-1}; \end{cases} \\ 0 & \text{otherwise.} \end{cases}$$

We measure success over a single day only, 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 banks 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. This occurrence is also problematic. 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.

Because day-to-day, exchange-rate changes approximate a martingale process, we interpret successful interventions as highly persistent, if not permanent, shocks to an exchange rate. A successful sterilized intervention will send the exchange rate on an alternative path, but one that remains consistent with existing and unchanged market fundamentals. Our methodology cannot answer questions about the duration of exchange-rate shocks.

Neely (2005) argues that our counting method biases the success counts. He assumes that exchange rates and intervention are jointly determined in the following system:

(7) $$\Delta S_t = \beta I_t + \mathrm{u}_{1t}$$

(8) $$I_t = \delta \Delta S_t + \mathrm{u}_{2t},$$

where $\delta < 0$ implies leaning against the wind. Under the null hypothesis that intervention is ineffective, $\beta = 0$, the conditional expectation of the exchange-rate change is:

(9) $$E(\Delta S_t \mid I_t) = \rho \frac{\sigma_1}{\sigma_2} I_t,$$

where

(10) $\rho = \delta \cdot f(\sigma_1, \sigma_2) < 0$, since δ <0. This suggests the following conditional expectation for the exchange-rate change associated with intervention sales (equation 11) and purchases (equation 12) of foreign exchange:

(11) $E(\Delta S_t \mid I_t > 0) < 0$

(12) $E(\Delta S_t \mid I_t < 0) > 0.$

Even though intervention has no effect under the null hypothesis, the conditional expectation of the exchange-rate change is negative when the central bank sells foreign exchange and positive when the central bank buys foreign exchange, implying that the success counts are similarly biased.

The assumption underlying Neely's model seems very strong. Equation 8, the reaction function, implies that the central bank routinely knows something about the future change in the exchange rate that the market does not know, since ΔS_t measures the exchange-rate change from the opening of day t to the opening of the next day, t+1. While central bankers may believe that the market is inefficient (disorderly), it is unlikely that central bankers routinely have better information about *future* exchange rates than the market.

We assume instead that intervention is conditioned only on past information, $I_t|\Omega_{t-1}$, where Ω_{t-1} refers to information existing prior to the intervention decision. Under our assumption, $\delta = 0$ in equation 8, and $E(\Delta S_t|\Omega_{t-1}) = 0$. We assume that the exchange markets have the same information set as the central bank, but that the exchange markets do not conform to some official interpretation of this information. That is the nature of the asymmetric information problem. Under our assumption, the counts are not biased. Intervention can conceivably impart some new information relevant to price discovery, but that information is contained in Ω_{t-1}, as in 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. Our tests are designed 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 events to be independent and does not depend on a presumed probability of an individual success. To apply the Henriksson and Merton method 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 successfully affects exchange rates if the success count exceeds the expected number by two standard deviations. We reject the null and conclude that intervention fails 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 the number that would randomly occur given the near martingale nature of daily exchange-rate changes.

This approach also assumes that intervention does not affect the fundamental macroeconomic determinants of exchange rates. This assumption seems appropriate given that monetary authorities routinely sterilize their 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, 2 March 1973 through 19 March 1997.[4] During these 6,274 business days, the United States intervened on 971 days against German marks and on 243 days against Japanese yen.[5] The first intervention against German marks took place on 10 July 1973, and the first intervention against Japanese yen followed on 24 January 1974. The United States intervened against German marks roughly four times as often as it intervened against Japanese yen. Roughly 60 percent of U.S. interventions against Japanese yen involved purchases of yen, suggesting that the United States tended to encourage dollar depreciations against the yen. Interventions against the German mark were more evenly distributed between purchases and sales of marks, with only a slight bias toward mark purchases.

The first column in table 1 lists the success criteria for the German mark (top section) and Japanese yen (bottom section). The second column shows official U.S. intervention purchases and sales. Between 2 March 1973 and 19 March 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 29.0 percent, were successful under criterion SC1; 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 through 3, absent any consideration of intervention. The dollar appreciated against the German mark—whether or not the United States intervened against marks—on 2,951, or 47.0 percent, of the 6,274 business days in our sample.

The final two columns in table 1 refer to the hypergeometric distribution. Is successes are a hypergeometric random variable, then in a sample of 6,274 observations with a virtual success rate of 47.0 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. This value is so low that individuals in the market could have bet against the United States—bought German marks on day *t*—and made money on average. From an expectations-channel perspective, U.S. sales of German marks signaled that the dollar would depreciate on the same day as the intervention. Similar results hold for purchases of German marks and for both U.S. official purchases and sales of Japanese yen.

In contrast to the results under success criterion SC1, the success counts under SC2, 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. intervention exhibits some short-term ability to lean against the wind. When the dollar is depreciating and the United States sells foreign exchange, the dollar continues to depreciate, but it does so by less than on the day prior to the intervention. Likewise, when the dollar is appreciating and the United States buys foreign exchange, the dollar continues to appreciate, but it does so by less than on the day prior to the intervention.

While the successes under criterion SC2 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 SC2 criterion.

The final, general success criterion, SC3, combines SC1 and SC2. Generally, we expect that 60 percent of all interventions will be successful under at least one of our success criteria purely by chance. The number of successes under SC3 are—with two exceptions—no better than random. The first exception is U.S. sales of German marks, whose successes fall more than two

standard deviations below the expected number. The second exception is U.S. sales of Japanese yen, whose successes fall exactly two standard deviations above the expected number.

5. Robustness

We repeated our counting analysis for various subperiods as a robustness check. First, we divided the sample into two parts: The first was from 2 March 1973, when generalized floating was just beginning, through 17 April 1981, when the Reagan administration announced its minimalist intervention strategy, and the second was from 20 April 1981, the start of the minimalist period, through 19 March 1997, the end of our sample period. Next, we divided these two subperiods further. Among these subdivisions, two are particularly noteworthy for their heavy intervention activity: One, which goes from 15 September 1977 through 5 October 1979, was a period of fairly intensive intervention to limit the dollar's depreciation; another, going from 1 April 1985 through 29 April 1988, encompasses the heavy, coordinated Plaza and Louvre interventions.

Table 2, which summaries our key results for the various subperiods, suggests that our overall conclusions about intervention and leaning against the wind are not robust across all time periods and are not necessarily robust across both currencies within any time period. (Tables comparable to table 1 for each of the subperiods appear in the appendix as tables A1 through A8.) In table 2, an F indicates that the number of successes falls more than two standard deviations below the expected number; an S indicates that the number of successes is more than two standard deviations above the expected number, and an R indicates that the number of successes falls within two standard deviations of the expected number. Between 2 March 1973 and 17 April 1981, for example, U.S. intervention against German marks seemed consistently to exhibit a leaning-against-the-wind effect, but interventions against Japanese yen were not

effective according to any of our criteria. Between 20 April 1981 and 19 March 1997, U.S. intervention against German marks seemed to lean against the wind, as did U.S. sales of Japanese yen. Although U.S. purchases of Japanese yen scored no better than random, the number of success (21) was substantially above the expected number of successes (15).

Even when we focus on our two narrower subperiods of intensive U.S. intervention, the results are still not robust across time periods and currencies. Between 15 September 1977 and 5 October 1979, the dollar generally depreciated. The United States bought German marks on 175 days and sold German marks on 58 days. These interventions had a leaning–against-the-wind effect. The United States intervened far less in Japanese yen, selling yen on only 10 days and buying yen on only 19 days. All of these interventions exhibited a leaning-against-the-wind effect except for U.S. sales of Japanese yen, whose success count was no better than random. During the Plaza and Louvre interventions, 1 April 1985 through 29 April 1988, none of the interventions appear successful under any criterion, except U.S. sales of German marks. All in all, U.S. intervention seems to have been a rather hit-or-miss proposition.

6. Conditional Probability

Tables 1 and 2 describe unconditional probabilities of success under our three success criteria. The United States, however, could have conceivably increased its odds of success by altering certain aspects of the interventions it undertook. Tables 3 and 4 present a series of probit regressions that measure the effect of a number of variables on the likelihood of an intervention's success. Each table shows estimates for the entire sample period, but each also contains estimates over a subperiod, which allows us to incorporate variables for German and Japanese intervention. Data on German intervention against U.S. dollars are available between 1 January 1976 and 29 December 1995, and data on Japanese intervention against U.S. dollars are available

between 1 January 1991 and 19 March 1997. The independent variables that appear individually in the probit regressions appear in first column of tables 3 and 4. The dependent variable in all cases is the general success criteria, SC3. Table 3 pertains to U.S. intervention against German marks and table 4 pertains to U.S. intervention against Japanese yen.

A few variables appear to be statistically significant in specific cases, such as lagged same-type German intervention, but the only variable that consistently explains the likelihood of success across all of the estimates in tables 3 and 4 is the dollar amount of a U.S. intervention. The results for the other variables that sometimes appear significant are not robust to changes in the sample size (necessary to include foreign intervention) or across both currencies. Coordination, for example, is significant for the German mark at *t*, but lowers the likelihood of success. At time *t*+1, however, coordination is not significant. Given the time difference between Frankfurt and New York and given the timing convention in this paper, German intervention overlaps two consecutive U.S. observations, so both of these should be compared with U.S. intervention on day *t*. Similarly, the coordination dummy for Japanese intervention on day *t* is significant and suggests that coordinated intervention increases the likelihood of success. Given the time difference between Tokyo and New York and given our timing conventions, comparing Japanese intervention at *t*+1 with SC3 at time *t* seems more appropriate, but when we do so, the coefficient suggests that coordinated intervention lowers the likelihood of success.

Figure 1 uses the coefficient estimates for the amount of U.S. intervention (exclusive of foreign-intervention variables) from tables 3 and 4 to estimate how the probability of success responds to the size of intervention. Over the entire sample, the unconditional probability of a successful intervention against German marks using the SC3 criterion is 57 percent, while the probability of a virtual success is slightly higher, around 60 percent. Based on our estimates, a

U.S. intervention of $110 million against German marks has a 60 percent probability of being successful. Over the entire sample period, 2 March 1973 through 19 March 1997, fewer than 25 percent of U.S. interventions against German marks were greater than $100 million. The mean intervention in our sample was $80 million, while the median intervention was only $31 million. The largest intervention against German marks amounted to $950 million. This amount is more than twice as large as was necessary to virtually guarantee success, about $400 million, and seems inefficiently large.

Similarly, large interventions against Japanese yen increased the probability of success. Over the entire sample, the unconditional probability of success (SC3) for interventions against Japanese yen was 65 percent, somewhat higher than the probability of a virtual success at roughly 60 percent. We find that a U.S. intervention against Japanese yen of $187 million had a 65 percent probability of success. Over the entire sample, the average U.S. intervention against Japanese yen was $131 million, and the median intervention against Japanese yen equaled only $90 million. The largest intervention against Japanese yen amounted to $800 million. As is the case with U.S. intervention against German marks, this amount seems inefficiently large. We estimate that a U.S. intervention of roughly $400 million is sufficient to virtually guarantee success against Japanese yen, all else constant.

7. Conclusion

U.S. intervention in the era of floating exchange rates has been, by and large, ineffectual. In this paper, we assessed U.S. intervention in terms of two criteria: Was intervention associated with an appreciation or depreciation of the dollar, and if not, did intervention then lean against the wind? In terms of achieving either of these criteria, roughly 60 percent of all U.S. interventions since the inception of floating exchange rates in March 1973 have been successful,

but we expected that amount purely by chance given the near-martingale nature of day-to-day exchange-rate movements. This overall result occurs primarily because U.S. intervention sales and purchase of foreign exchange are generally incapable of promoting a dollar appreciation or depreciation. This negative result is robust across time periods and currencies. We find, however, that U.S. intervention is able to moderate same-day movements in exchange rates relative to the previous days, that is, to lean against the wind.[6] Neely and Weller (1997) and LeBaron (1999) cite leaning-against-the-wind intervention strategy as a reason for their finding that intervention improves the profitability of technical trading rules. Our second result, however, is not robust across all time periods and currencies. Moreover, less than one-fourth of all U.S. interventions were successful according to this leaning-against-the-wind criterion.

The only conditioning variable that seemed to consistently increase the likelihood of success—measured broadly—was the dollar amount of a U.S. intervention. Large intervention may better convey private information. Our analysis suggests, however, that amounts much in excess of $400 million were excessively large. It does not follow that conducting all interventions in excess of $400 million would guarantee success. Large intervention may only seem large because the typical intervention over the sample periods was so much smaller.

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 rough 20 percent during the Louvre period (1987-1990). Dominquez and Frankel (1993a) also found in favor of coordination. Humpage and Osterberg (1990), 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.

Overall, the limited success record for U.S. intervention and its lack of robustness across time periods and currencies within a particular time period argue against an activist approach to U.S. intervention. The results suggest that U.S. monetary authorities do not routinely have an information advantage over private traders in the foreign exchange market.

References

Alkeminders, G. J. 1995. *Foreign-Exchange Intervention, Theory and Evidence*, Hants, United Kingdom: Edward Elgar Publishing.

Baillie, R., Humpage, O. and Osterberg W. 2000. Intervention from an Information Perspective. *Journal of International Financial Markets, Institutions and Money* 10: 3-4.

Bonser-Neal, C., Roley, V. V. and Sellon, G. H., Jr. 1998. Monetary Policy Actions, Intervention, and Exchange Rates: A Reexamination of the Empirical Relationships Using Federal Funds Rate Target Data. *Journal of Business* 71 (2): 147-177.

Chaboud, A.P., and Humpage, O.F. 2003. An Analysis of Japanese Foreign-Exchange Interventions, 1991 – 2002. Federal Reserve Bank of Cleveland Working Paper no. 03-09.

Chang Y., and Taylor, S. 1998. Intraday Effects of Foreign-Exchange Intervention by the Bank of Japan. *Journal of International Money and Finance* 17 (1): 191-210.

Cheung, Y., and Chinn, M.D. 2001. Currency Traders and Exchange Rate Dynamics: A Survey of the U.S. Market. Journal of international Money and Finance 20: 439-471.

Dominguez, K., and Frankel, J. 1993a. Does Foreign-Exchange Intervention Matter? The Portfolio Effect. *American Economic Review* 83: 1356-1369.

Dominguez, K., and Frankel, J. 1993b. *Does Foreign-Exchange Intervention Work?* Washington, D.C: Institute for International Economics.

Dominguez, K. 2003. The Market Microstructure of Central Bank Intervention. *Journal of International Economics* 59: 25-45.

Edison, H. 1993. The Effectiveness of Central Bank Intervention: A Survey of the Literature after 1982. Princeton University, Special Papers in International Economics, No. 18.

Evans, M., and Lyons, R. 2001. Portfolio Balance, Price Impact and Secret Intervention. NBER Working Paper No. 8356.

Fatum, R., and Hutchison, M. 2002. ECB Foreign-Exchange Intervention and the EURO: Institutional Framework, News and Intervention. *Open Economies Review*, 13: 413-425.

Goodhart, C. A. E., and Hesse, T. 1993. Central Bank Forex Intervention Assessed in Continuous Time. *Journal of International Money and Finance* 12 (4): 368-89.

Humpage, O.F. 1999. U.S. Intervention: Assessing the Probability of Success. *Journal of Money Credit and Banking* 31 (4):731-747.

Humpage, O.F. 2000. The United States as an Informed Foreign-Exchange Speculator. *Journal of International Financial Markets, Institutions, and Money* 10: 287-302.

Humpage, O.F., and Osterberg, W.P. 1992. Intervention and the Foreign Exchange Risk Premium: An Empirical Investigation of Daily Effects. *Global Finance Journal* 3: 23-50.

LeBaron, B. 1999. "Technical Trading Rule Profitability and Foreign Exchange Intervention. Journal of International Economics 49: 125-143.

LeCourt, C., and Raymond, H. 2003. Central Bank Interventions in the Light of Survey Results. unpublished.

Lyons, R. 2001. *The Microstructure Approach to Exchange Rates*. The MIT Press: Cambridge, Mass.

Mussa, M. 1981. The Role of Official Intervention. Occasional Paper No. 6, New York: Group of Thirty.

Neely, C. J. 2001. The Practice of Central Bank Intervention: Looking Under the Hood. *Central Banking* XI (2): 24-37.

Neely, C. J. 2005. An Analysis of Recent Studies of the Effectiveness of Foreign Exchange Intervention. Federal Reserve Bank of St. Louis *Review* 87 (6):685-717.

Neely, C. J. and Weller, P. 1997. Technical Analysis and Central Bank Intervention. Journal of International Money and Finance. 20 (7): 949-970.

Popper H., and Montgomery, J. 2001. Information Sharing and Central Bank Intervention in the Foreign-Exchange Market. *Journal of International Economics* 55: 295-316.

Reitz, S. and Taylor M.P. 2008, Japanese and Federal Reserve Intervention in the Yen-US Dollar Market: A Coordination Channel of FX Operations? (unpublished).

Sarno, L., and Taylor, M.P. 2001. The Official Intervention in the Foreign-Exchange Market: Is It Effective and, If So, How Does It Work? *Journal of Economic Literature* 39: 839-868.

Endnotes

[1] Edison (1993), Alkeminders (1995), Baillie, et al. (2000), Nealy (2005), and Sarno and Taylor (2001) provide excellent surveys of intervention.

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

[3] We repeated our count calculation using a closing exchange rate (4:00 p.m.) with $\Delta S_t = S_t - S_{t-1}$. Our results were similar to the results report in the next section.

[4] The United States did not abruptly end its intervention on 19 March 1997. U.S. interventions began to taper off in the early 1990s. After August 1995, the United States intervened once against Japanese yen on 17 June 1998 and once against euros on 22 September 2000. These last two interventions are the only instances of U.S. intervention during the floating exchange rate era not included in our analysis. Our exchange rate data determined our sample, which ends on 19 March 1997. These data are a consistent daily series provided by the Federal Reserve Bank of New York that starts in early March 1973.

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

[6] Using this same counting technique, Humpage (1999, 2000) reached a similar conclusion for U.S. interventions in the last half of the 1980s.

Figure 1: Intervention Amount and the Probability of Success

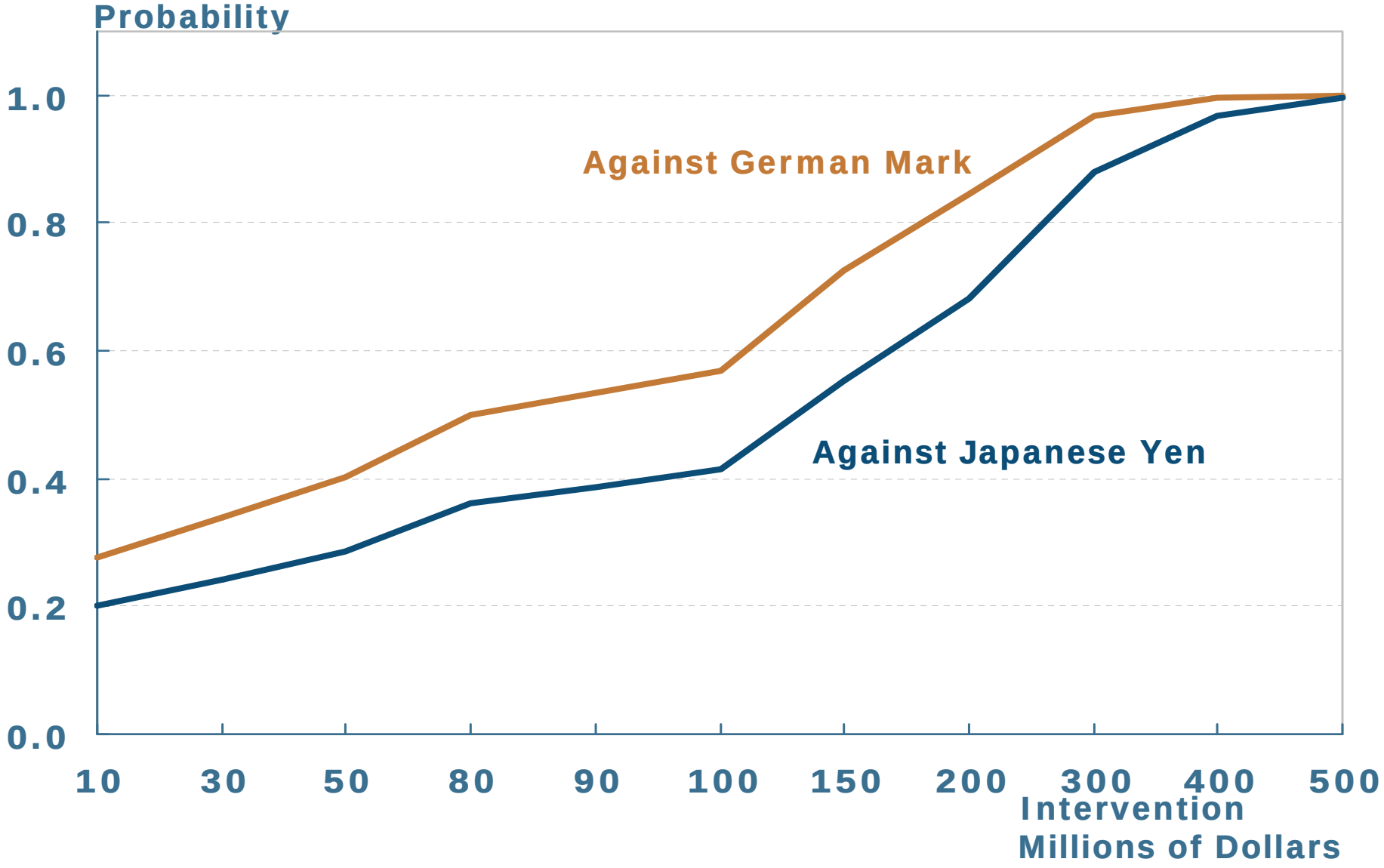

TABLE A8: SUCCESS COUNTS FOR U.S. INTERVENTION 2 May 1988 to 19 March 1997
OPENING BID QUOTES

	TOTAL	INTERVENTION SUCCESSES		VIRTUAL SUCCESSES		EXPECTED SUCCESSES	STANDARD DEVIATION
German Marks	#	#	%	#	%	#	#
Observations:	2318						
Criterion SC1							
sell marks	44	22	50.0	1121	48.4	21	3
buy marks	111	54	48.6	1100	47.5	53	5
total	155	76	49.0				
Criterion SC2							
sell marks	44	6	13.6	274	11.8	5	2
buy marks	111	17	15.3	305	13.2	15	3
total	155	23	14.8				
Criterion SC3							
sell marks	44	28	63.6	1395	60.2	26	3
buy marks	111	71	64.0	1405	60.6	67	5
total	155	99	63.9				
Japanese Yen							
Observations:	2317						
Criterion SC1							
sell yen	31	15	48.4	1156	49.9	15	3
buy yen	87	38	43.7	1064	45.9	40	5
total	118	53	44.9				
Criterion SC2							
sell yen	31	8	25.8	272	11.7	4	2
buy yen	87	14	16.1	305	13.2	11	3
total	118	22	18.6				
Criterion SC3							
sell yen	31	23	74.2	1428	61.6	19	3
buy yen	87	52	59.8	1369	59.1	51	5
total	118	75	63.6				

TABLE 1: SUCCESS COUNTS FOR U.S. INTERVENTION 2 March 1973 to 19 March 1997
Opening Bid Quotes

	TOTAL	INTERVENTION SUCCESSES		VIRTUAL SUCCESSES		EXPECTED SUCCESSES	STANDARD DEVIATION
German Marks	#	#	%	#	%	#	#
Observations:	6274						
Criterion SC1							
sell marks	469	136	29.0	2951	47.0	220.6	10
buy marks	502	192	38.2	3007	47.9	240.6	11
total	971	328	33.8				
Criterion SC2							
sell marks	469	117	24.9	820	13.1	61.30	7
buy marks	502	110	21.9	807	12.9	64.57	7
total	971	227	23.4				
Criterion SC3							
sell marks	469	253	53.9	3771	60.1	282	10
buy marks	502	302	60.2	3814	60.8	305	10
total	971	555	57.2				
Japanese Yen							
Observations:	6274						
Criterion SC1							
sell yen	94	47	50.0	3000	47.8	45	5
buy yen	149	63	42.3	2836	45.2	67	6
total	243	110	45.3				
Criterion SC2							
sell yen	94	19	20.2	740	11.8	11	3
buy yen	149	28	18.8	829	13.2	20	4
total	243	47	19.3				
Criterion SC3							
sell yen	94	66	70.2	3740	59.6	56	5
buy yen	149	92	61.7	3665	58.4	87	6
total	243	158	65.0				

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:	*SC1*	*SC1*	*SC2*	*SC2*	*SC3*	*SC3*	*SC1*	*SC1*	*SC2*	*SC2*	*SC3*	*SC3*
buy/sell foreign exchange :	*buy*	*sell*	*buy*	*sell*	*buy*	*sell*	*buy*	*sell*	*buy*	*sell*	*buy*	*sell*
2 March 73 - 19 March 97:	**F**	**F**	**S**	**S**	**F**	**R**	**R**	**R**	**S**	**S**	**R**	**R**
2 March 73 - 17 April 81:	**F**	**F**	**S**	**S**	**F**	**R**	**R**	**R**	**R**	**R**	**R**	**R**
2 March 73 - 14 September 77:	**F**	**F**	**S**	**S**	**F**	**R**	(none)	**R**	(none)	**R**	(none)	**R**
15 September 77 - 5 October 79:	**F**	**F**	**S**	**S**	**F**	**F**	**F**	**R**	**R**	**S**	**R**	**R**
8 October 81 - 17 April 81:	**F**	**F**	**S**	**S**	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**
20 April 81 - 19 March 97:	**R**	**R**	**S**	**S**	**R**	**R**	**R**	**R**	**S**	**R**	**R**	**R**
20 April 81 - 29 March 85:	**R**	**R**	**R**	**S**	**R**	**R**	(none)	**R**	(none)	**S**	(none)	**R**
1 April 85 - 29 April 88:	**R**	**R**	**S**	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**
2 May 88 - 19 March 97:	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**S**	**R**	**R**	**R**

KEY:

F = *Observed number of successes falls below the expected number of successes by more that two standard deviations.*

S = *Observed number of successes exceeds the expected number of successes by more than tow standard deviations.*

R = *Obeserved number of success falls within two standard deviations of the expected number of successes.*

TABLE 3: INDIVIDUAL DETERMINANTS OF THE LIKELIHOOD OF A SUCCESSFUL INTERVENTION AGAINST GERMAN MARKS

INDEPENDENT VARIABLES	**Constant** *t-statistic:*	**Coefficient** *t-statistic:*	**Log Likelihood:**	**Likelihood Ratio test:**
estimation period: 2 March 1973 - 19 March 1997				
constant only	0.180		-663.1	
	4.46			
amount of U.S. intervention (abs. value)	0.107	0.001	-659.6	6.99
	2.18	*2.60*		
buy foreign exchange (dummy)	0.099	0.158	-661.2	3.83
	1.71	*1.96*		
lagged same-type intervention (dummy)	0.018	0.329	-654.8	16.44
	0.32	*4.05*		
lagged different-type intervention (dummy)	0.204	-0.47	-659.92	6.29
	4.90	*-2.49*		
consecutive interventions (days)	0.116	0.02	-661.74	2.65
	2.05	*1.62*		
elapse since last intervention (days)	*0.165*	*0.003*	-661.86	2.41
	3.94	*1.43*		
compatible change in fed funds or discount rate (dummy)	0.183	-0.436	-662.8	0.60
	4.50	*-0.77*		

		5% p-value	*10% p-value*
Critical Chi-Square value	1 d.f.	3.84	2.71

TABLE 3 (CONTINUED) : INDIVIDUAL DETERMINANTS OF THE LIKELIHOOD OF A SUCCESSFUL INTERVENTION AGAINST GERMAN MARKS

INDEPENDENT VARIABLES	**Constant** *t-statistic:*	**Coefficient** *t-statistic:*	**Log Likelihood:**	**Likelihood Ratio test:**
estimation period: 1 January 1976 - 29 December 1995				
constant only	0.160		-494.6	
	3.42			
amount of U.S. intervention (abs. value)	0.046	0.001	-489.9	9.43
	0.77	*3.01*		
buy foreign exchange (dummy)	*0.10*	*0.12*	-493.7	1.75
	1.48	*1.32*		
coordinated intervention; German on t (dummy)	0.336	-0.353	-487.5	14.12
	5.04	*-3.75*		
coordinated intervention; German on t+1 (dummy)	0.216	-0.130	-493.6	1.89
	3.48	*-1.37*		
total intervention with German at t (abs. value)	0.176	-0.0001	-494.48	0.19
	2.95	*-0.431*		
total intervention with German at t+1 (abs. value)	0.16683	*0.00*	-494.56	0.03
	2.795	*-0.17*		
lagged same-type intervention (dummy)	0.017	0.289	-489.8	9.49
	0.26	*3.08*		
lagged different-type intervention (dummy)	0.177	-0.50	-492.8	3.57
	3.71	*-1.87*		
consecutive interventions (days)	0.12	0.01	-494.2	0.75
	1.90	*0.87*		
elapse since last intervention (days)	0.14	0.003	-493.28	2.58
	2.91	*1.47*		
compatible change in fed funds or discount rate (dummy)	0.163	-0.417	-494.3	0.543
	3.47	*-0.73*		

		5% p-value	*10% p-value*
Critical Chi-Square value	1 d.f.	3.84	2.71

TABLE 4: INDIVIDUAL DETERMINANTS OF THE LIKELIHOOD OF A SUCCESSFUL INTERVENTION AGAINST JAPANESE YEN

INDEPENDENT VARIABLES	**Constant** *t-statistic:*	**Coefficient** *t-statistic:*	**Log Likelihood:**	**Likelihood Ratio test:**
estimation period: 2 March 1973 - 19 March 1997				
constant only	0.375		-157.9	
	4.54			
amount of U.S. intervention (abs. value)	0.232	0.001	-156.2	3.40
	2.04	*1.79*		
buy foreign exchange (dummy)	0.531	-0.249	-156.8	2.13
	3.90	*-1.45*		
lagged same-type intervention (dummy)	0.303	0.151	-157.5	0.84
	2.67	*0.92*		
lagged different-type intervention (dummy)	not	applicable		
consecutive interventions (days)	0.391	-0.01	-157.9	0.04
	3.27	*-0.19*		
elapse since last intervention (days)	0.347	0.001	-157.2	1.48
	4.03	*1.05*		
compatible change in fed funds or discount rate (dummy)	0.371	5.771	-157.5	-157.5
	4.489	*0.001*		
	5% p-value	*10% p-value*		
Critical Chi-Square value 1 d.f.	3.84	2.71		

TABLE 4 (CONTINUED): INDIVIDUAL DETERMINANTS OF THE LIKELIHOOD OF A SUCCESSFUL INTERVENTION AGAINST JAPANESE YEN

INDEPENDENT VARIABLES	**Constant** *t-statistic:*	**Coefficient** *t-statistic:*	**Log Likelihood:**	**Likelihood Ratio test:**
estimation period: 1 January 1991- 19 March 1997				
constant only	0.605		-12.9	
	2.12			
amount of U.S. intervention (abs. value)	-0.706	0.005	-9.6	6.58
	-1.11	*2.09*		
coordinated intervention; Japanes on t (dummy)	-5.703	6.416	-11.5	2.73
	0.00	*0.00*		
coordinated intervention; Japanese on t+1 (dummy)	1.335	-1.221	-10.9	3.92
	2.52	*-1.87*		
total intervention with Japanese at t (abs. value)	-0.333	0.001	-11.0	3.81
	-0.54	*1.63*		
total intervention with Japanese at t+1 (abs. value)	0.794	-0.0003	-12.8	0.24
	1.63	*-0.48*		
buy foreign exchange (dummy)	*0.97*	-1.642	-10.4	5.06
	2.75	*-2.14*		
lagged same-type intervention (dummy)	0.634	-0.203	-12.9	0.06
	2.05	*-0.25*		
lagged different-type intervention (dummy)	not	applicable		
consecutive interventions (days)	0.837	-0.203	-12.9	0.06
	0.86	*-0.25*		
elapse since last intervention (days)	0.85	-0.003	-12.3	1.24
	2.30	*-1.12*		
compatible change in fed funds or discount rate (dummy)	not	applicable		
	5% p-value	*10% p-value*		
Critical Chi-Square value 1 d.f.	3.84	2.71		

TABLE A1: SUCCESS COUNTS FOR U.S. INTERVENTION 2 March 1973 to 17 April 1981
OPENING BID QUOTES

	TOTAL	INTERVENTION SUCCESSES		VIRTUAL SUCCESSES		EXPECTED SUCCESSES	STANDARD DEVIATION
German Marks	#	#	%	#	%	#	#
Observations:	2121						
Criterion SC1							
sell marks	391	103	26.3	964	45.5	178	9
buy marks	348	124	35.6	1021	48.1	168	9
total	739	227	30.7				
Criterion SC2							
sell marks	391	100	25.6	296	14.0	55	6
buy marks	348	82	23.6	276	13.0	45	6
total	739	182	24.6				
Criterion SC3							
sell marks	391	203	51.9	1260	59.4	232	9
buy marks	348	206	59.2	1297	61.2	213	8
total	739	409	55.3				
Japanese Yen							
Observations:	2121						
Criterion SC1							
sell yen	11	7	63.6	976	46.0	5	2
buy yen	31	11	35.5	910	42.9	13	3
total	42	18	42.9				
Criterion SC2							
sell yen	11	1	9.1	255	12.0	1	1
buy yen	31	7	22.6	298	14.0	4	2
total	42	8	19.0				
Criterion SC3							
sell yen	11	8	72.7	1231	58.0	6	2
buy yen	31	18	58.1	1208	57.0	18	3
total	42	26	61.9				

TABLE A2: SUCCESS COUNTS FOR U.S. INTERVENTION 2 March 1973 to 14 September 1977
OPENING BID QUOTES

	TOTAL	INTERVENTION SUCCESSES		VIRTUAL SUCCESSES		EXPECTED SUCCESSES	STANDARD DEVIATION
German Marks	#	#	%	#	%	#	#
Observations:	1184						
Criterion SC1							
sell marks	161	45	28.0	541	45.7	74	6
buy marks	176	67	38.1	560	47.3	83	6
total	337	112	33.2				
Criterion SC2							
sell marks	161	34	21.1	151	12.8	21	4
buy marks	176	45	25.6	163	13.8	24	4
total	337	79	23.4				
Criterion SC3							
sell marks	161	79	49.1	692	58.4	94	6
buy marks	176	112	63.6	723	61.1	107	6
total	337	191	56.7				
Japanese Yen							
Observations:	1184						
Criterion SC1							
sell yen	0	0	na	524	44.3	0	0
buy yen	2	2	100.0	478	40.4	1	1
total	2	2	100.0				
Criterion SC2							
sell yen	0	0	na	139	11.7	0	0
buy yen	2	0	na	181	15.3	0	1
total	2	0	na				
Criterion SC3							
sell yen	0	0	na	663	56.0	0	0
buy yen	2	2	100.0	659	55.7	1	1
total	2	2	100.0				

TABLE A3: SUCCESS COUNTS FOR U.S. INTERVENTION 15 September 1977 to 5 October 1979
OPENING BID QUOTES

	TOTAL	INTERVENTION SUCCESSES		VIRTUAL SUCCESSES		EXPECTED SUCCESSES	STANDARD DEVIATION
German Marks	#	#	%	#	%	#	#
Observations:	537						
Criterion SC1							
sell marks	175	43	24.6	222	41.3	72	5
buy marks	58	16	27.6	284	52.9	31	4
total	233	59	25.3				
Criterion SC2							
sell marks	175	49	28.0	95	17.7	31	4
buy marks	58	12	20.7	53	9.9	6	2
total	233	61	26.2				
Criterion SC3							
sell marks	175	92	52.6	317	59.0	103	5
buy marks	58	28	48.3	337	62.8	36	3
total	233	120	51.5				
Japanese Yen							
Observations:	537						
Criterion SC1							
sell yen	10	6	60.0	248	46.2	5	2
buy yen	19	5	26.3	255	47.5	9	2
total	29	11	37.9				
Criterion SC2							
sell yen	10	1	10.0	72	13.4	1	1
buy yen	19	6	31.6	68	12.7	2	1
total	29	7	24.1				
Criterion SC3							
sell yen	10	7	70.0	320	59.6	6	2
buy yen	19	11	57.9	323	60.1	11	2
total	29	18	62.1				

TABLE A4: SUCCESS COUNTS FOR U.S. INTERVENTION 8 October 1979 to 17 April 1981
OPENING BID QUOTES

	TOTAL	INTERVENTION SUCCESSES		VIRTUAL SUCCESSES		EXPECTED SUCCESSES	STANDARD DEVIATION
German Marks	#	#	%	#	%	#	#
Observations:	400						
Criterion SC1							
sell marks	55	15	27.3	201	50.3	28	3
buy marks	114	41	36.0	177	44.3	50	4
total	169	56	33.1				
Criterion SC2							
sell marks	55	17	30.9	50	12.5	7	2
buy marks	114	25	21.9	60	15.0	17	3
total	169	42	24.9				
Criterion SC3							
sell marks	55	32	58.2	251	62.8	35	3
buy marks	114	66	57.9	237	59.3	68	4
total	169	98	58.0				
Japanese Yen							
Observations:	400						
Criterion SC1							
sell yen	1	1	100.0	204	51.0	1	0
buy yen	10	4	40.0	177	44.3	4	2
total	11	5	45.5				
Criterion SC2							
sell yen	1	0	0.0	44	11.0	0	0
buy yen	10	1	10.0	49	12.3	1	1
total	11	1	9.1				
Criterion SC3							
sell yen	1	1	100.0	248	62.0	1	0
buy yen	10	5	50.0	226	56.5	6	2
total	11	6	54.5				

TABLE A5: SUCCESS COUNTS FOR U.S. INTERVENTION 20 April 1981 to March 19, 1997
OPENING BID QUOTES

	TOTAL	INTERVENTION SUCCESSES		VIRTUAL SUCCESSES		EXPECTED SUCCESSES	STANDARD DEVIATION
German Marks	#	#	%	#	%	#	#
Observations:	4153						
Criterion SC1							
sell marks	78	33	42.3	1987	47.8	37	4
buy marks	154	68	44.2	1986	47.8	74	6
total	232	101	43.5				
Criterion SC2							
sell marks	78	17	21.8	524	12.6	10	3
buy marks	154	28	18.2	531	12.8	20	4
total	232	45	19.4				
Criterion SC3							
sell marks	78	50	64.1	2511	60.5	47	4
buy marks	154	96	62.3	2517	60.6	93	6
total	232	146	62.9				
Japanese Yen							
Observations:	4153						
Criterion SC1							
sell yen	83	40	48.2	2024	48.7	40	5
buy yen	118	52	44.1	1926	46.4	55	5
total	201	92	45.8				
Criterion SC2							
sell yen	83	18	21.7	485	11.7	10	3
buy yen	118	21	17.8	531	12.8	15	4
total	201	39	19.4				
Criterion SC3							
sell yen	83	58	69.9	2509	60.4	50	4
buy yen	118	73	61.9	2457	59.2	70	5
total	201	131	65.2				

TABLE A6: SUCCESS COUNTS FOR U.S. INTERVENTION 20 April 1981 to 29 March 1985
OPENING BID QUOTES

	TOTAL	INTERVENTION SUCCESSES		VIRTUAL SUCCESSES		EXPECTED SUCCESSES	STANDARD DEVIATION
German Marks	#	#	%	#	%	#	#
Observations:	1030						
Criterion SC1							
sell marks	1	0	0.0	517	50.2	1	1
buy marks	24	6	25.0	464	45.0	11	2
total	25	6	24.0				
Criterion SC2							
sell marks	1	0	0.0	118	11.5	0	0
buy marks	24	7	29.2	146	14.2	3	2
total	25	7	28.0				
Criterion SC3							
sell marks	1	0	0.0	635	61.7	1	0
buy marks	24	13	54.2	610	59.2	14	2
total	25	13	52.0				
Japanese Yen							
Observations:	1030						
Criterion SC1							
sell yen	0	0	na	519	50.4	0	0
buy yen	11	4	36.4	449	43.6	5	2
total	11	4	36.4				
Criterion SC2							
sell yen	0	0	na	102	9.9	0	0
buy yen	11	5	45.5	142	13.8	2	1
total	11	5	45.5				
Criterion SC3							
sell yen	0	0	na	621	60.3	0	0
buy yen	11	9	81.8	591	57.4	6	2
total	11	9	81.8				

TABLE A7: SUCCESS COUNTS FOR U.S. INTERVENTION 1 April 1985 to 29 April 1988
OPENING BID QUOTES

	TOTAL	INTERVENTION SUCCESSES		VIRTUAL SUCCESSES		EXPECTED SUCCESSES	STANDARD DEVIATION
German Marks	#	#	%	#	%	#	#
Observations:	805						
Criterion SC1							
sell marks	33	11	33.3	349	43.4	14	3
buy marks	19	8	42.1	421	52.3	10	2
total	52	19	36.5				
Criterion SC2							
sell marks	33	11	33.3	132	16.4	5	2
buy marks	19	4	21.1	80	9.9	2	1
total	52	15	28.8				
Criterion SC3							
sell marks	33	22	66.7	481	59.8	20	3
buy marks	19	12	63.2	501	62.2	12	2
total	52	34	65.4				
Japanese Yen							
Observations:	805						
Criterion SC1							
sell yen	52	25	48.1	349	43.4	23	3
buy yen	20	10	50.0	412	51.2	10	2
total	72	35	48.6				
Criterion SC2							
sell yen	52	10	19.2	111	13.8	7	2
buy yen	20	2	10.0	84	10.4	2	1
total	72	12	16.7				
Criterion SC3							
sell yen	52	35	67.3	460	57.1	30	3
buy yen	20	12	60.0	496	61.6	12	2
total	72	47	65.3				