Is Sterilized Foreign Exchange Intervention Effective After All?

An Event Study Approach

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Abstract

Central banks actively engage in sterilized foreign exchange market intervention despite numerous empirical studies indicating that these operations do not systematically affect the exchange rate. Are these policies misguided and central bankers irrational? Or is evidence showing the effectiveness of sterilized intervention being overlooked? This paper argues the latter, providing evidence on the effectiveness of sterilized intervention using an event study approach linking intervention with systematic exchange rate changes. We argue that this is an important methodological innovation since studies using time-series techniques are limited by the nature of the data: intense and sporadic bursts of intervention activity juxtaposed against exchange rates that change almost continuously on a daily basis. The event study framework used in standard finance studies, by contrast, is ideally suited to this circumstance. Focusing on daily US official intervention operations, we identify separate intervention "episodes" and analyze the subsequent effect on the exchange rate. Using the matched-sample mean test and the non-parametric sign test of the median, we find strong evidence that sterilized intervention systemically affects the exchange rate. These results are especially strong when episodes are distinguished by the intervention currency, the form of intervention (sales or purchases of foreign exchange), and exchange rate developments immediately prior to the intervention activity.

1.0 Introduction

The motivation for central banks to actively pursue sterilized intervention policies in foreign exchange markets is somewhat of a mystery. Few doubt that unsterilized intervention may affect nominal exchange rates by changing interest rates and monetary aggregates. The effect of sterilized intervention on exchange rates, however, is very weak at best. The "portfolio balance" channel, through which sterilized intervention changes the currency denomination of relative asset supplies and thereby the exchange risk premium if assets are imperfect substitutes, has received little empirical support (e.g. Rogoff, 1984; Humpage, 1991; Edison, 1993; and Sweeney, 1995, 1996).

Evidence in favor of a "signaling" channel, through which sterilized intervention may provide new information about policy intentions and hence future fundamentals, is similarly weak. Lewis (1995) finds that US intervention helps predict changes in monetary indicators within a two-week period, attributing this not to signaling but rather to the particular nature of the Federal Reserve operating procedures (especially the required reserves accounting period) which induces a lag between intervention and sterilization. Kaminsky and Lewis (1996) find that US intervention often "signals" monetary policy indicators in the opposite direction of that predicted by the conventional signaling hypothesis. Fatum and Hutchison (1999), using dailiy data and a GARCH model, find that that intervention does not systematically signal a particular direction of future monetary policy (proxied by changes in the Federal Funds Future market) but does increase the uncertainty over the direction of policy.

Why should central banks continue to pursue sterilized intervention in the face of substantial evidence that it does not work? We argue in this article that central bank foreign exchange operations may make sense in that sterilized intervention is effective. The problem rests with the limitations of empirical methods attempting to link sterilized intervention with exchange rate movements. The methodology employed in all of the studies noted above is some form of time-series analysis. One difficulty in applying standard time series methods in this

context is that intervention operations on a daily basis are relatively infrequent relative to "tranquil" periods. In the United States, for example, there are frequently long periods of no official intervention in the foreign exchange markets followed by short bouts of intense activity (Figures 1 and 2). Exchange rates typically move rather significantly on a day-to-day basis, while official intervention activities are sporadic. Viewed in this context, perhaps it is not surprising that time series methods find very weak or no evidence of a systematic association between exchange rate movements and intervention operations.

Although standard time-series methods are problematic in dealing with data such as that characterizing exchange rate movements and official intervention operations, this setting fits well with event study methodology. This is our contribution. Focusing on daily US official intervention operations, we identify separate intervention "episodes" and, using an event study methodology, analyze the subsequent effect on the exchange rate.[1] An "event" in this context may be considered each episode of intense intervention activity, generally lasting a few days. By construction, an event study is a very general test of a particular hypothesis and does not rely on a well-specified structural model of exchange rate determination. In this sense we impose few priors or theoretical structure in the statistical tests. Given the lack of consensus over the appropriate model of exchange rates, this seems an advantage.

An important aspect of our research is the careful identification of events. In this context, we are careful to distinguish between various types of episodes of intervention. We make three distinctions between episodes: official US sales or purchases of foreign exchange; official purchases against the German Mark (DEM) or against the Japanese Yen (JPY); and the market context prior to the time of intervention, i.e. whether the US Dollar (USD) is appreciating or depreciating prior to the intervention activity. All three distinctions prove to be important in clearly identifying systematic effects of intervention on exchange rates. Using the matched-pair mean test and the non-parametric sign of the median test, we find strong evidence that intervention affects the exchange rate when episodes are distinguished by the intervention

currency, whether the form of intervention (sales or purchases of foreign exchange), and exchange rate developments immediately prior to the intervention activity.

The rest of the article is organized as follows. The next section discusses the data, and section 3 explains the identification of intervention episodes and the event study methodology. Section 4 presents the empirical results. Section 5 concludes the paper.

2. Data and Identification of Intervention Episodes

The intervention variable is daily Federal Reserve System sales (negative values) and purchases (positive values) of USD (millions) against DEM and JPY, respectively, in the foreign exchange market. This is official foreign exchange market intervention data, provided by the Board of Governors of the Federal Reserve System, from which we exclude so-called customer transactions. Customer transactions, which sometimes can be timed to constitute a type of "passive" intervention, consist of Fed sales or purchases of foreign exchange directly with customers, usually central banks or governments, that would otherwise need to transact with market agents. Excluding these transactions is in line with previous research in this area.

During our sample period, September 20, 1982 to December 31, 1993, the Fed sold USD against DEM on 146 days and purchased USD against DEM on 73 days. The bulk of USD sales or purchases against DEM on active days was usually relatively small in magnitude, with trades of less than 150 USD. During our sample period the Fed sold USD against JPY on 114 days and purchased USD against JPY on 70 days. As with the case of foreign exchange market intervention against DEM, the bulk of USD sales or purchases against JPY on active days was usually trades of less than 150 USD. Figure 1 (Figure 2) illustrates the sporadic nature of Fed intervention operations against the DEM (JPY), where on a daily basis long spells of no activity ("tranquil" periods) are inter-spaced with relatively intense activity over a number of days.

3.0 Event Study Design

The initial task of conducting an event study is to define the event of interest and to identify the period over which the security prices will be examined. This period is referred to as the event window and consists of the prior-event days, the event day (or days), and the post-event days.[2]

In our context, we are interested in assessing the success of intervention in moving exchange rates. The task is to define and identify the events of intervention and to define and identify the number of days before and after the event, respectively, over which the pattern of exchange rate movements is analysed. Finally, a measure of success— what constitutes an economically meaningful exchange rate response-- must be established.

3.1 Defining Events

Most events in finance -- mergers and acquisitions, earning announcements, issues of new debt, and so on—- occur only once over a given period of time. That is, the event takes place on a single day. Defining each day that the Fed is active in the foreign exchange market as a separate event, however, does not meaningfully structure the data set. Nor does it capture the policy intent of the intervention at a particular time. For example, the eight continuous days of official intervention against the DEM in early 1985 (when the Fed attempted to depreciate the US dollar) might be viewed as a single event.

The general problem in defining events is that, if the event period were set too short, then one actual policy episode of intervention may be incorrectly identified as two or more defined events. This potentially leads to a number of overlapping events. On the other hand, if the event period were set too long, then two actual policy episodes-- different policy decisions to intervene in the market-- may be incorrectly identified as a single event.

We define an event as a period of days with official intervention in one direction (purchases or sales), against one or more foreign currencies, possibly including a number of days

with no intervention. This leaves the choice of how many consecutive days of no intervention we will allow for while still considering the surrounding days of intervention to be part of the same event. Although this decision seems somewhat arbitrary in principle, a careful investigation of the intervention time-series shows, in Figures 1 and 2, that there are either few days, generally less than fifteen, or several days, generally more than thirty, between days of Fed presence in the foreign exchange market.[3]

We considered several event definitions, distinguished by the maximum number of days of "tranquillity" (consecutive days of no intervention) between days of intervention, which identify a single episode. Two, five, ten, and fifteen day periods were considered and the maximum fifteen day period was accepted. Choosing a period with more than fifteen days of tranquillity during an event episode seems unappealing, losing the intuition that a particular episode constitutes a single event. On the other hand, shorter periods created a number of instances of overlap of pre- and post-event windows. In fact, thirteen days (3 cases) was the maximum consecutive days of tranquillity obtained during a single event. The vast majority of the events had less than five days of tranquillity and the results are not sensitive to this choice.

3.2 Event Windows and Sample Selection

The length of the prior-event and the post-event periods, respectively, are set to ten days each. This is consistent with standard event studies using financial data.

In terms of the beginning sample date, US intervention policy up until late 1982 was little delineated and not suitable for an event study of this form. Intervention during this period was characterized by the Fed's presence in the foreign exchange market on an almost daily basis with frequent shifts in direction (purchases or sales of foreign exchange). In order to make the event study approach meaningful—to avoid events of only one or very few days of Fed intervention immediately followed by new events of Fed intervention against the same foreign currency in the opposite direction-- our sample period is set to begin on September 20, 1982.[4]

3.3 Defining a Successful Event

There is no convention of what constitutes a "successful" intervention episode. We define success as intervention episode that effectively dampens exchange rate movements (e.g. Humpage, 1996). US intervention is deemed a success if the sale (purchase) of foreign exchange is (i) associated with USD appreciation (depreciation) or (ii) is associated with smaller USD depreciation (appreciation) compared to the previous day. Using the first criterion, which we term a "reversal effect", an event of US intervention is deemed a success if a sale (purchase) of foreign exchange is associated with USD appreciation (depreciation) during the post-event period. Using the second criterion, which we term the "dampening effect", success is indicated when the sale (purchase) of foreign exchange is associated with significantly smaller USD depreciation (appreciation) in the post-event period compared with the prior-event period.

3.4 Conditional Events

An unappealing implication of these criteria for success arise if the Fed were to pursue a *leaning with the wind* intervention policy, i.e. attempt to support or accelerate an ongoing exchange rate movement in the same direction. In this instance, a purchase (sale) of foreign exchange followed by a stronger USD depreciation (appreciation) is deemed unsuccessful, even though the exchange rate moves as intended.

To deal with this issue, we also divide the intervention episodes into two parts: intervention not conditioned on the preceding exchange rate movement, and intervention conditioned on the preceding exchange rate movement ("conditional events"). Our conditional events—distinguishing intervention purchases (sales) of foreign exchange when the prior period is marked by USD appreciation (depreciation). Our objective here is to distinguish periods where the Fed is apparently trying to "lean against the wind" and either slow or reverse the preceding exchange rate movement.

3.5 Non-parametric Sign for the Median and Paired-Sample Means Tests

We employ two types of statistical tests in this regard. The first test is the non-parametric sign test for the median. This statistic tests whether "reversals" in the direction of the exchange rate change following intervention events, e.g. from appreciation to depreciation, or "dampenings" of the exchange rate change following intervention events, eg. smaller appreciation, are random or systematic. The sign test for the median is applicable to any continuous distribution and the null hypothesis is that the population corresponding to the sample has a median value equal to zero against the alternative that the median is not zero. If the hypothesis is true, the probability of a positive value is the same as that of a negative value, hence =0.5. Then the random variable x (= number of positive (negative) values among n sample observations) has a binomial distribution with =0.5. A significant sign test of the median indicates a change in the direction of the exchange rate trend. For details on this test in event studies, see MacKinlay, 1997.[5]

The second test is the matched-sample means test (see, for example, Ben-Horim and Levy, 1984, p. 458). This tests whether there is a significant shift in the exchange rate change between the prior- and post-event periods (following the intervention event). Since we are able to match the observations of one sample (before) with the observations of the second sample (after), we can use the matched sample means test. A matched sample test should yield more precise statistical inferences. For each observation of the first sample, we obtain the matched value in the second sample and calculate the difference (D_i). The sample mean and standard deviation values are calculated in the usual way. Assuming that values (exchange rate changes) from both samples are normally distributed, we may apply the standard t-statistic (distributed with n-1 degrees of freedom, where n is the number of paired observations) to test whether the mean change has

shifted between the two samples. We identify the paired sample means test with our "dampening effect" since it indicates (at the minimum) slowing of dollar appreciation or depreciation.

4.0 Results

Tables 1 and 2 present the events that we identify using our criteria for intervention against the DEM and JPY, respectively. Each table provides a detailed description of the behaviour of exchange rates during the event and during the prior- and post-event windows, the amount (and direction) of the intervention operation, and the number of intervention days. Turning to the success of intervention operations, tables 3-5 separate the events into USD sales and purchases, and compares changes in exchange rates during the prior-event period with those of the post-event period. Table 3 presents the non-parametric sign of the median and matched-sample means tests for the DEM intervention events. Table 4 presents the analogous tests for the JPY intervention events, and Table 5 presents the combined tests where intervention is grouped for both currencies.

4.1 DEM Intervention

The US intervened against the DEM on 26 separate episodes (using our definition of events) during the sample period, shown in Table 1, and 20 of these cases were associated with multiple days of active intervention. Comparing the direction of intervention during the event with the change in the exchange rate over the preceding period (10-day prior-event window), 20 events appear to signal a "leaning against the wind" intervention and 6 events are in line with "leaning with the wind."[6] Furthermore, the direction of the exchange rate fluctuation during the post-event period was consistent with the direction of the intervention operation in 17 of the 26 events, while 19 of the 26 events were successful according to either the reversal or the dampening criterion.[7]

Table 3 divides the 26 episodes into cases of USD sales (16 events) and purchases (10 events) and further into the conditional events. Sales (purchases) of USD for DEM were preceded by USD appreciation (depreciation) on 13 (7) occasions. 12 of the 16 events of USD sales against DEM were successful thus, based on the non-parametric sign for the median test, rejecting randomness at the 95 percent significance level. Focussing on leaning against the wind events of USD sales against DEM, 11 of 13 events were successful, thus rejecting randomness at the 99 percent level. The table also shows that 7 of 10 events of USD purchases against DEM were successful thus failing to reject randomness at conventional significance levels. However, all 7 of the "leaning against the wind" events of USD purchases against DEM were successful, rejecting randomness at the 99 percent significance level.

Table 3 also presents the results of paired sample means test. Prior (post) to intervention events when the Fed *sold* USD in the foreign exchange market the average exchange rate change was 0.12 percent (-0.12 percent). Prior (post) to intervention events when the Fed *purchased* USD in the foreign exchange market the average exchange rate change was –0.17 (0.05) percent. US intervention against the DEM was, on average, associated with a reversal of the preceding trend. In the formal tests, three of four cases clearly rejected (at the 95 percent level or higher) the null hypothesis of no difference in means. That is, intervention appears to have had a "dampening" effect on exchange rate changes.

4.2 JPY Intervention

For the case of US intervention against the JPY, Table 2 describes the behaviour of the JPY/USD exchange rate around 22 separate events (of which 15 lasted more than a single day). Comparing intervention during the event with the change in the exchange rate over the preceding period (10-day prior-event window), 17 events appear to signal a "leaning against the wind" intervention and 5 events are in line with "leaning with the wind". Furthermore, the direction of the exchange rate fluctuation during the post-event period was consistent with the

direction of the intervention operation in 14 of the 23 events, while 16 of the 22 events were successful according to either the reversal or the dampening criterion.

Table 4 shows that 7 of 12 events of sales of USD for JPY, and 5 of 8 events of USD *sales* in a "leaning against the wind" environment, were successful. This frequency of successful events is not significantly different from random occurrences in this case. However, 9 of 10 events of *purchases* of USD and 9 of 9 events of leaning against the wind purchases of USD were successful, strongly rejecting randomness at the 95 and the 99 percent level of significance, respectively.

Moreover, the average change of the JPY/USD exchange rate during the prior-event period leading up to a Fed *purchase* of USD is negative (-0.21), while positive (0.15), on average, during the post-event period. This suggests that US intervention purchases of USD against JPY were, on average, associated with reversals of ongoing trends. In cases where the Fed *sold* USD, the direction did not change but the average rate of appreciation slowed from 0.09 (prior event window) to 0.04 (post event window). This indicates a dampening effect. These observations are supported by the matched sample means tests—in every case the null hypothesis of an unchanged mean change was rejected at the 99 percent level of significance.

4.3 Combined Sample

Table 5 combines the DEM and JPY intervention events into one sample. The statistics from this exercise strengthen our other findings. In every case, there is strong evidence that the direction or the rate of change of the exchange rate movement systemically changes as intended following an intervention episode (at the 95 percent level of significance or higher). The differences in the mean values of the exchange rate change between the prior- and post-event periods were also highly significant in all four cases (at the 99 percent level).

5.0 Conclusion

Using paired-means and non-parametric sign tests, we find strong evidence that intervention affects the exchange rate when episodes are distinguished by the intervention currency, whether the form of intervention (sales or purchases of foreign exchange), and exchange rate developments immediately prior to the intervention activity. Though simple methodologically, looking at intervention operations in this way provides strong support of the view that sterilized intervention plays an effective role in stabilizing the exchange rate. Our results help to explain why central banks continue to pursue sterilized intervention despite substantial academic skepticism over the effectiveness of these operations.

Table 1   US Intervention against the DEM

Date of event	Average daily percentage change in the DEM/USD exchange rate over preceding 10 days (a)	Level of DEM/USD exchange rate first day of intervention	Total amount of intervention (b) (millions USD)	Number of days of intervention during event	Average daily percentage change in the DEM/USD exchange rate over subsequent 10 days (c)
Oct 4, 82 - Oct 5, 82	0.098	2.554	-40	2	0.063
Jul 29, 83 - Aug 4, 83	0.196	2.649	-183	4	-0.133
Dec 5, 83	0.058	2.744	-50	1	0.102
Jan 5, 84 - Jan 9, 84	-0.603	2.798	143	2	-0.060
May 24, 84	-0.034	2.743	-135	1	-0.119
Sep 7, 84 - Oct 17, 84	0.074	2.987	280	5	-0.294
Jan 22, 85 - Mar 1, 85	0.049	3.171	-594	8	0.071
Sep 23, 85 - Nov 7, 85	-0.291	2.732	-1861	14	-0.238
Mar 11, 87	0.122	1.871	-30	1	-0.241
Apr 24, 87 - Jun 3, 87	-0.060	1.791	782	7	0.103
Aug 4, 87 - Aug 10, 87	0.012	1.892	-631	4	-0.419
Sep 2, 87	-0.170	1.803	50	1	0.035
Oct 27, 87 - Jan 13, 88	-0.305	1.764	2784	23	0.295
Apr 14, 88 - Apr 15, 88	0.178	1.663	240	2	0.082
Jun 27, 88 - Sep 26, 88	0.541	1.819	-5066	26	-0.204
Nov 17, 88 - Dec 2, 88	-0.258	1.731	630	4	0.200
Jan 6, 89 - Feb 6, 89	0.209	1.814	-2230	15	-0.257
Mar 8, 89 - Jun 30, 89	0.062	1.859	-6319	39	-0.123
Aug 11, 89 - Oct 11, 89	0.121	1.939	-2582	23	-0.406
Mar 5, 90 - Mar 7, 90	0.308	1.704	-200	2	0.009
May 29, 90 - Jul 17, 90	0.314	1.672	1000	17	-0.362
Feb 4, 91 - Feb 12, 91	-0.448	1.465	1336	7	0.377
Mar 11, 91 - Mar 22, 91	0.372	1.580	-370	4	0.220
May 17, 91	-0.156	1.738	-50	1	0.068
Jul 12, 91	0.215	1.789	-100	1	-0.286
Jul 20, 92 - Aug 24, 92	-0.386	1.482	1270	5	0.148

a)   Average daily percentage change in the DEM/USD exchange rate over the ten business days prior to first day of the event.

b)   Positive values represent intervention in support of the USD, i.e. purchase of USD, while negative values represent intervention aimed at reducing the USD, i.e. sale of USD.

c)   Average daily percentage change in the DEM/USD exchange rate over the ten business days succeeding the last day of the event.

Table 2   US Intervention against JPY

Date of event	Average daily percentage change in the JPY/USD Exchange rate over preceding 10 days (a)	Level of JPY/USD exchange rate first day of intervention	Total amount of intervention (b) (millions USD)	Number of days of intervention during event	Average daily percentage change in the JPY/USD exchange rate over subsequent 10 days (c)
Oct 4, 82 - Oct 6, 82	0.214	273.50	-51	3	0.174
Aug 1, 83 - Aug 4, 83	0.021	243.70	-71	3	-0.025
Oct 31, 83 - Nov 1, 83	-0.004	234.05	-30	2	0.078
Feb 1, 85	0.027	256.75	-49	1	0.041
Sep 23, 85 - Nov 7, 85	-0.145	231.90	-1440	20	-0.236
Jan 28, 87	-0.376	151.75	50	1	0.128
Mar 23, 87 - May 4, 87	-0.116	150.25	3985	18	0.061
Jun 2, 87 - Jun 3, 87	0.227	142.25	103	2	0.129
Aug 24, 87 - Sep 2, 87	-0.600	142.00	390	5	0.116
Oct 28, 87 - Jan 21, 88	-0.152	139.18	1817	20	0.102
Mar 25, 88 - Apr 15, 88	-0.185	125.35	578	5	0.084
Oct 31, 88 - Dec 2, 88	-0.103	125.50	1970	13	0.246
Mar 30, 89	0.169	132.95	-100	1	-0.057
Apr 28, 89 - Oct 12, 89	-0.001	132.85	-10577	63	-0.178
Nov 20, 89 – Jan 18, 90	0.085	144.50	-750	5	-0.084
Feb 23, 90 - Apr 9, 90	-0.038	146.92	-1580	13	0.013
Mar 15, 91	0.223	137.20	-30	1	0.245
Jan 17, 92	0.299	127.45	-50	1	0.237
Feb 17, 92 - Feb 20, 92	0.188	127.93	-150	2	0.246
Apr 27, 93	-0.206	111.25	200	1	-0.018
May 27, 93 - Jun 8, 93	-0.259	107.80	1066	3	0.464
Aug 19, 93	-0.310	103.95	165	1	0.195

a)   Average daily percentage change in the JPY/USD exchange rate over the ten business days prior to first day of the event.

b)   Positive values represent intervention in support of the USD, i.e. purchase of USD, while negative values represent intervention aimed at reducing the USD, i.e. sale of USD.

c)   Average daily percentage change in the JPY/USD exchange rate over the ten business days succeeding the last day of the event.

Table 3   US Intervention against the DEM

Non-parametric sign test

	Number of Events	Number of Successes (a)	Probability of Observed Number of Successes (b)
USD Sales	16	12	3.84%
USD Sales when USD Appreciates (c)	13	11	1.12%
USD Purchases	10	7	17.19%
USD Purchases when USD Depreciates (c)	7	7	0.78%

Matched pairs test

	Number of Events		t-statistic (d)
USD Sales	16		
Prior event average percentage change (e)		0.12	
Post event average percentage change (e)		-0.12	
Difference in means		-0.236	-3.57
USD Sales when USD Appreciates (c)	13	-0.305	-4.67
USD Purchases	10		
Prior event average percentage change (e)		-0.17	
Post event average percentage change (e)		0.05	
Difference in means		0.219	1.46
USD Purchases when USD Depreciates (c)	7	0.475	5.48

Notes

a. Intervention is successful if the sale (purchase) of foreign exchange is associated with USD appreciation (depreciation).

b. Based on a binomial probability distribution with the probability of an individual success of 50 %.

c. The Fed pursuing a leaning against the wind intervention policy.

d. Matched pairs (paired comparison) of exchange rate growth rate changes prior and post each event, assuming both series are normally distributed.

e. The average of the average daily percentage change in the exchange rate over preceding and subsequent 10 days, respectively.

Table 4 US Intervention against the JPY

Non-parametric sign test

	Number of Events	Number of Successes (a)	Probability of Observed Number of Successes (b)
USD Sales	12	7	38.72%
USD Sales when USD Appreciates (c)	8	5	36.33%
USD Purchases	10	9	1.07%
USD Purchases when USD Depreciates (c)	9	9	0.20%

Matched pairs test

	Number of Events		t-statistic (d)
USD Sales	12		
Prior event average percentage change (e)		0.09	
Post event average percentage change (e)		0.04	
Difference in means		-0.049	-5.58
USD Sales when USD Appreciates (c)	8	-0.056	-4.33
USD Purchases	10		
Prior event average percentage change (e)		-0.21	
Post event average percentage change (e)		0.15	
Difference in means		0.359	13.26
USD Purchases when USD Depreciates (c)	9	0.409	16.37

Notes

a. Intervention is successful if the sale (purchase) of foreign exchange is associated with USD appreciation (depreciation).

b. Based on a binomial probability distribution with the probability of an individual success of 50 %.

c. The Fed pursuing a leaning against the wind intervention policy.

d. Matched pairs (paired comparison) of exchange rate growth rate changes prior and post each event, assuming both series are normally distributed.

e. The average of the average daily percentage change in the exchange rate over preceding and subsequent 10 days, respectively.

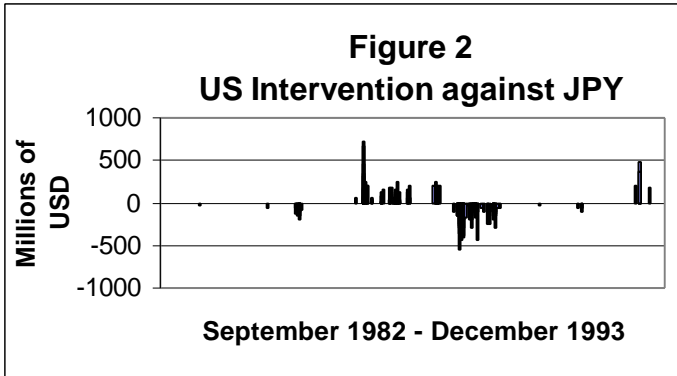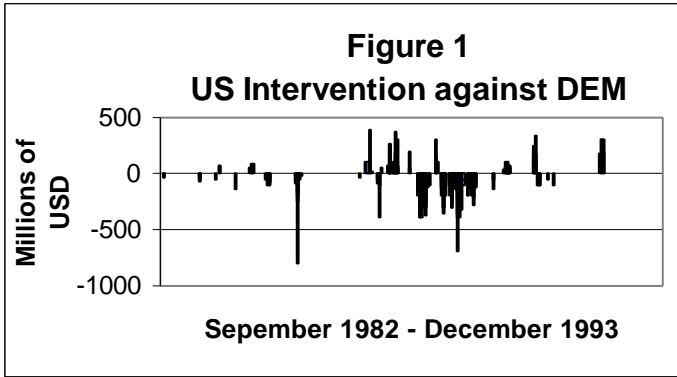## Table 5   US Intervention against the JPY and DEM

Non-parametric sign test

	Number of Events	Number of Successes (a)	Probability of Observed Number of Successes (b)
USD Sales	28	19	4.36%
USD Sales when USD Appreciates (c)	21	16	1.33%
USD Purchases	20	16	0.59%
USD Purchases when USD Depreciates (c)	16	16	0.00%

Matched pairs test

	Number of Events		t-statistic (d)
USD Sales	28		
Prior event average percentage change (e)		0.11	
Post event average percentage change (e)		-0.05	
Difference in means		-0.156	-18.82
USD Sales when USD Appreciates (c)	21	-0.210	-18.90
USD Purchases	20		
Prior event average percentage change (e)		-0.19	
Post event average percentage change (e)		0.10	
Difference in means		0.289	14.90
USD Purchases when USD Depreciates (c)	16	0.438	31.56

Notes

a. Intervention is successful if the sale (purchase) of foreign exchange is associated with USD appreciation (depreciation).

b. Based on a binomial probability distribution with the probability of an individual success of 50 %.

c. The Fed pursuing a leaning against the wind intervention policy.

d. Matched pairs (paired comparison) of exchange rate growth rate changes prior and post each event, assuming both series are normally distributed.

e. The average of the average daily percentage change in the exchange rate over preceding and subsequent 10 days, respectively.

Figure 1
US Intervention against DEM

Millions of USD

500
0
-500
-1000

Sepember 1982 - December 1993

Figure 2
US Intervention against JPY

Millions of USD

1000
500
0
-500
-1000

September 1982 - December 1993

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Endnotes

[1] The identification itself of separate intervention episodes is readily found in Dominguez and Frankel (1993) and Kaminsky and Lewis (1996).

[2] See MacKinlay (1997) for a recent survey on event study methodology.

[3] A detailed table listing all the events, duration of the events, number of days of intervention during each event, and so on is available from the authors upon request.

[4] Between January 2, 1975 and September 20, 1982 the Fed was active in the foreign exchange market on a total of 670 days.

[5] Despite the usefulness of the non-parametric rank test in event studies of finance, see MacKinlay (1997), Campbell and Wasley (1993) and Corrado (1989) for details, we find our number of events too small to apply this test procedure.

[6] For instance, a negative change in the exchange rate (a drop in the DEM per USD or JPY per USD) over the days preceding the event (USD depreciation), followed by a purchase of USD (a positive amount of intervention) identifies a leaning against the wind policy, aiming at breaking the ongoing trend. A negative change in the exchange rate over the ten preceding days, followed by a sale of USD (a negative amount of intervention) identifies a leaning with the wind policy, aiming at strengthening the ongoing trend.

[7] For instance, a USD purchase is aimed at strengthening the USD, and is therefore successful if the exchange rate increases over the post-event period relative to the prior-event period (again, a rise in the DEM/USD or the JPY/USD exchange rate identifies a USD appreciation).