Foreign Exchange Market Trading Volume and Federal Reserve Intervention

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Draft. July 14, 1999

Abstract: We find a large positive correlation between daily trading volume in currency futures markets and foreign exchange intervention by the Federal Reserve over the period 1979-1996. Neither contemporaneous nor predicted volatility can fully account for the increases in trading activity. Whether or not the intervention operation is publicly reported appears to be an important determinant of trading volume.

- The authors would like to thank Kathryn Dominguez for the intervention news data, Mico Loretan for his kernel density estimate software, and Hali Edison, Dale Henderson and Richard Lyons for their excellent comments. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or any other person associated with the Federal Reserve System.

1. Introduction

Researchers almost universally agree that sterilized central bank intervention in foreign exchange markets is unlikely to affect the level of exchange rates in the long term. In the very short term, however, central bank intervention is often associated with sharp price movements in currency markets, and reports of intervention are crucial pieces of information in these markets (Dominguez and Frankel, 1993; Goodhart and Hesse, 1993). As is the case for other financial asset prices, the process by which the Ainformational content@ of intervention and other market events is incorporated into currency prices is still poorly understood, and various models of price discovery in asset markets follow different approaches in mapping the link between the flow of information deemed relevant and the price of the asset. Most of the models, however, often descendants of the original Amixture of distribution hypothesis@ literature (Clark, 1973; Epps and Epps, 1976), predict that, as new information is being incorporated, increases in trading volume will accompany movements in prices. That prediction has been tested extensively in equity markets, but much less in foreign exchange markets, principally because of data constraints.

Among recent work on the price discovery process in foreign exchange markets, both the issue of what constitutes relevant information and the issue of how information is disseminated have been studied using price data. Andersen and Bollerslev (1998) find that their analysis of price volatility in the dollar-mark market is consistent with the hypothesis that public announcements as well as the trading process itself contain relevant information. Peiers (1997), examining high-frequency price quotes, studies information asymmetry among traders following Bundesbank intervention. She states that evidence of information-based leadership around times of central bank intervention should also be observable through changes in quantities traded.

This note presents evidence that, over the period 1979-1996, foreign exchange intervention operations by the Federal Reserve have been correlated with increases in currency trading volume in the dollar-yen and dollar-mark futures markets. These increases in trading volume do not appear to be fully explained by market volatility, in the sense that, even after conditioning for daily volatility, trading volume is higher on intervention days. For a portion of the sample, we are also able to differentiate between volume responses associated with announced versus secret interventions. This later point may shed some light on the relative importance of public announcements versus the trading process itself in the price discovery mechanism.

2. Data and methodology

Our study uses intervention and trading volume data in the dollar-yen and dollar-mark markets, covering the June 1979-March 1996 period at a daily frequency (4255 trading days). Intervention data were provided by the Federal Reserve Board (the data we use are not confidential). They consist of the daily amounts spent by the Federal Reserve and the U.S. Treasury on purchases or sales of US dollars in the yen (JY) and mark (DM) spot markets in New York. There are 450 Aintervention days@ in the mark and 211 in the yen during our sample period, with much of the difference due to the higher number of intervention days in the mark early in the period. The following unconditional and conditional probabilities of intervention on day t (with I for intervention and NI for no intervention) show that, besides being relatively rare, intervention operations are clustered in time.

DM: $p(I_t) = 0.1058$ $p(I_t/I_{t-1}) = 0.5889$ $p(NI_t/NI_{t-1}) = 0.9516$

JY: $p(I_t) = 0.0496$ $p(I_t/I_{t-1}) = 0.5261$ $p(NI_t/NI_{t-1}) = 0.9753$

For volume data, we use the total trading volume on all active futures contracts (usually four for each currency) on the International Monetary Market of the Chicago Mercantile Exchange, as collected by Tick Data Inc. These data are the only available source of currency market trading volume at daily frequency over our sample period, and have been used frequently as a proxy for overall spot market trading volume (e.g. Frankel and Froot, 1990; Jorion, 1996).[1] Daily trading volume increases dramatically over our sample period. In the mark, for instance, the mean number of contracts traded per day increases from less than 1000 in 1979 to more than 30,000 in the 1990s. To deal with this nonstationarity, we create the following detrended volume variable

1 Despite the common assertion that, in markets where both spots and futures trading volumes are observed, they are usually highly correlated, using futures volume data as a proxy for spot volume data requires caution. Trading in futures markets is only a small fraction of the overall currency trading, and it can be argued that whatever motivates a futures trader to hedge may not necessarily motivate a spot trader to buy or sell. Also, since the contracts are not cash-settled, high trading volumes, unlikely to be matched in spot markets, are often observed for a short period during the four settlement months. This adds noise to the volume series and raises the bar for statistical significance. The increasing use of electronic trading systems in the 1990s carries with it hopes that volume data for a large share of the market may be routinely available in the future.

in each currency. The variable, which we call ANVOL@, is the ratio of today's trading volume to a moving average of the previous 100 daily trading volumes:

$$\mathrm{NVOL}_t = \frac{vol_t}{\sum_{s=1}^{100} vol_{t-s}} \qquad (1)$$

3. Basic Results

We first compute the mean values of the detrended volume variable, NVOL, for the whole sample, on days with intervention, and on days without intervention. Table 1 reports these results for the two currencies. The table also reports a t-statistic for the difference of means between intervention and no-intervention days, and the p-value from the following simulation procedure. Using the transition probabilities for interventions reported above, we create 1000 simulated intervention series of length 4255 and match them with the actual detrended trading volume series. We then calculate the mean trading volumes on days with and without simulated intervention, and report as a bootstrap p-value the fraction of the 1000 replications where the difference in mean trading volume between intervention days and days without intervention is at least as large as in the actual data. This simulation procedure allows us to study the statistical significance of the difference in mean trading volumes without the assumption of a Gaussian distribution for the volume series. It also takes into account the clustering properties of the actual intervention series.

Table 1: Mean Detrended Trading Volume

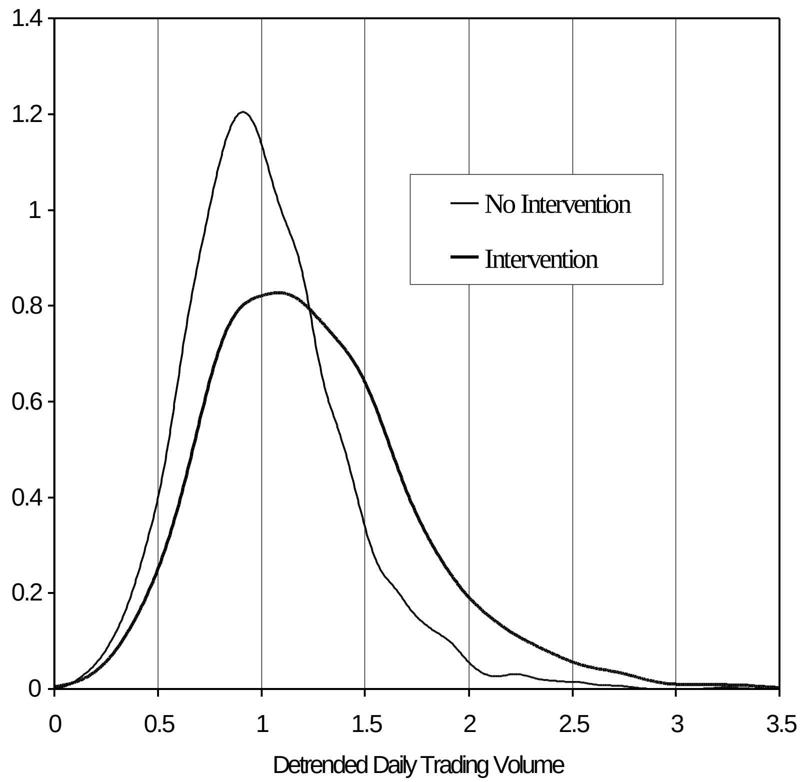
	Whole Sample	Intervention	No Intervention	T-statistic	Bootstrap p
DM NVOL	1.0443	1.2630	1.0184	9.39	0.000
JY NVOL	1.0413	1.2947	1.0281	7.34	0.000

The results are unequivocal. Trading volume on intervention days is, on average, higher than on days when the Fed chooses not to intervene. The differences in mean are highly statistically significant with or without the assumption of normality, which is not too surprising given the large number of observations, but the magnitude of the differences is also quite large.

The results show an increase in trading volume of over 25 percent in both currencies on intervention days relative to the mean volume of the 100 previous days.

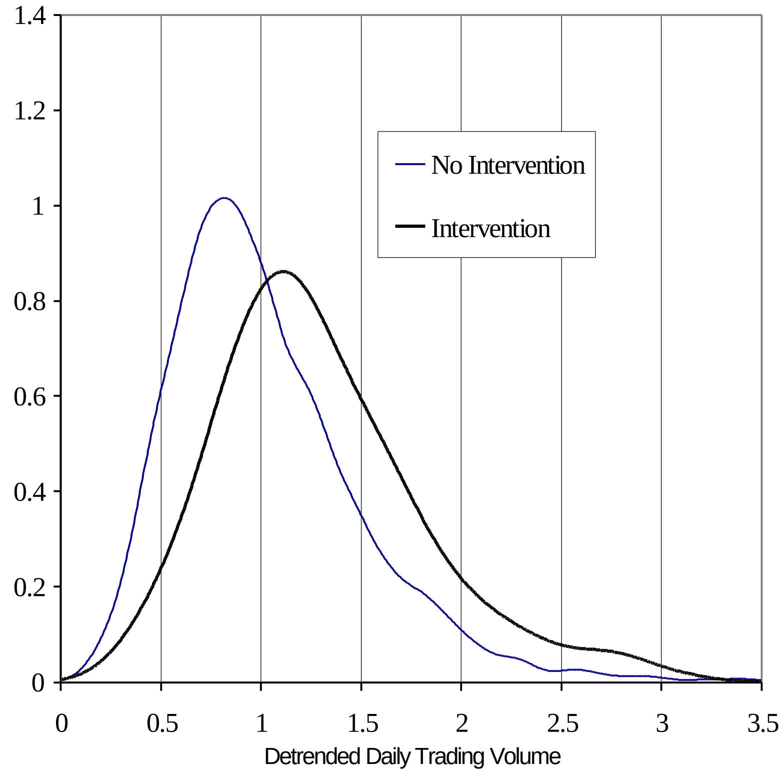
As shown by the next two figures, the high mean numbers on intervention days are not just the result of a few observations with high trading volume. Figures I and II show the kernel density estimates of the probability density functions of the NVOL variable, on days with intervention and on days without intervention. These density function are estimated using Gaussian kernels.[2]

Figure 1: PDF of Daily Trading Volume (DM)



2 The kernel bandwidth is chosen optimally using the "leave-one-out" cross-validation technique.

Figure 2: PDF of Daily Trading Volume (JY)



For both the yen and the mark, the whole distribution of daily trading volumes clearly shifts to the right for intervention days, indicating that, on a substantial majority of those days, abnormally high trading volumes are observed. Note also that, particularly in the mark, the dispersion of detrended trading volumes increases for intervention days.

The correlation between trading volume and intervention can not, however, be interpreted as proof that intervention causes an increase in trading. It may be that intervention truly causes a volume increase, it may be that high volume causes intervention, or it may be that a common process drives both intervention and volume.

4. Volatility and Trading Volume

One prime candidate to drive both intervention and volume is volatility. The link between volatility and volume is well documented, and recent work (Almekinders and Eijffinger, 1994; Baillie and Osterberg, 1997) has presented some evidence of a causal relationship between volatility and the decision to intervene. Dominguez (1998) finds that intervention is correlated with volatility, but argues, however, that the causation goes from intervention to volatility. In any case, if trading volume and intervention are each independently correlated with market volatility, one possible explanation for the results in Table 1 is therefore simple simultaneity. But it is, of course, likely that the relationship between intervention, volatility and volume is far more complex.

We investigate the relationship between volatility, volume and intervention in the following way. We gauge volatility using a scaled measure of the daily high-low range, creating the HILO variable:

$$HILO_t = [\log(high_t) - \log(low_t)].100 \quad (2)$$

We then rank the data in order of increasing daily volatility and break it down into quintiles. We report, for each quintile, the number of intervention operations, as well as the mean detrended trading volume and volatility on days with intervention and on days without. This method allows us to isolate the effects of intervention and volatility on trading volume, even in the presence of non-linear relationships. Tables 2 and 3 report the results.

Table 2: DM Mean Daily Trading Volume by High/Low Volatility Quintile

		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Intervention	N	n=109	n=81	n=84	n=83	n=93
	NVOL	1.0023	1.1466	1.2631	1.4056	1.5424
	HILO	0.3423	0.5313	0.6843	0.9056	1.6184
No Intervention	N	n=742	n=770	n=767	n=768	N=758
	NVOL	0.7688	0.8857	1.0143	1.1177	1.3010
	HILO	0.3521	0.5274	0.6881	0.9035	1.4637

Table 3: JY Mean Daily Trading Volume by High/Low Volatility Quintiles

		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Intervention	N	n=22	n=29	n=45	n=57	N=58
	NVOL	0.9724	1.0198	1.2063	1.2648	1.6525
	HILO	0.3058	0.4360	0.5622	0.7635	1.7511
No Intervention	N	n=829	n=822	n=806	n=794	n=793
	NVOL	0.6895	0.8702	1.0259	1.1492	1.4269
	HILO	0.2798	0.4279	0.5650	0.7588	1.3164

First, volatility and volume are, as expected, positively correlated for both currencies (NVOL always increases from quintile to quintile). Second, the frequency of intervention appears to be correlated with our measure of volatility for the yen, but not for the mark. Third, and most strikingly, within each quintile, the mean trading volume is, in every case, higher for intervention days than for days without intervention. Intervention appears therefore to be associated with an additional boost in trading volume beyond what the link between volatility and volume would be expected to generate.

The high-low range used above is often considered to be the best measure of market volatility for data at a daily frequency (Parkinson, 1980; Rogers and Stachell, 1991). It appears likely, however, that an intervention operation on a particular day will affect the high-low range on the same day, with the direction of the effect depending on the direction of the intervention operation relative to the market trend (Awith the wind@ or Aagainst the wind@). Since this could potentially bias our results (one way or the other), we address this issue by repeating the exercise of Tables 2 and 3 using, as a measure of volatility, the predicted daily conditional variance from a GARCH (1, 1) model. The model is fitted to the series of log-differences of daily closing prices for each currency, yielding the following parameter estimates, with h_t representing conditional variance, and r_t daily returns:

DM: $h_t = 0.908\, h_{t-1} + 0.070\, r^2_{t-1}$ (3)

JY: $h_t = 0.896\, h_{t-1} + 0.064\, r^2_{t-1}$

Table 4 reports, for both currencies, the number of intervention operations and the mean detrended volume by GARCH (1,1) volatility quintile.

Table 4: Mean Volume Movement by GARCH (1,1) Volatility Quintiles

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
DM #INT.	n=162	n=61	N=73	n=80	n=74
DM NVOL (Int.)	1.2400	1.4410	1.2601	1.2369	1.1979
DM NVOL (No Int.)	0.9530	0.9654	1.0682	1.0431	1.0559
JY #INT.	n=20	n=36	N=73	n=80	n=74
JY NVOL (Int.)	1.5212	1.3183	1.2404	1.3073	1.2446
JY NVOL (No Int.)	0.9201	0.9803	1.0675	1.0646	1.1205

Again, within each quintile, and for both currencies, mean trading volume is higher for intervention days than for days without intervention. This is additional evidence against the possibility that all we are observing is simultaneity. In addition, the correlation between trading volume and the GARCH conditional variance appears very poor on intervention days, and only marginal on days without intervention.

5. Intervention News and Trading Volume

We use a data set of news reports of intervention operations over the period 1983-1990 compiled by Dominguez and Frankel (1993) to study mean trading volumes movements under three sets of circumstances. An Aannounced@ intervention occurs when the Federal Reserve conducts an intervention operation and news stories correctly report activity in foreign exchange markets by the central bank. A Asecret@ intervention occurs when there is central bank activity in foreign exchange markets but no news report appears. A Afalse@ intervention occurs when news reports of intervention appear but the Federal Reserve does not intervene in that particular currency. Table 5 reports the mean volume movements in both currencies broken down into these categories.

Table 5: Mean Trading Volume Movements and News Reports (1983-1990)

	All	No Interv.	Intervention	Announced	Secret	False
DM	n=1942	n=1743	n=199	n=144	n=55	N=64
DM NVOL	1.044	1.036	1.107	1.146	1.005	1.027
JY	n=1942	n=1768	n=174	n=128	n=46	n=80
JY NVOL	1.031	1.007	1.272	1.315	1.153	1.141

The announcement effect is large in both currencies, with trading volume appreciably higher when intervention is announced than when it is not.[3] Trading volume on days with secret intervention is very low for the mark (lower than on days without intervention), but somewhat higher for the yen. Note that this is an instance where inferring a direction of causality may be difficult, as some researchers (Goodhart and Hesse, 1993; Hung,1995) have argued that a central bank may prefer to intervene secretly on days with a low trading volume.[4]

The announcement effect, while obviously very important, may not fully explain the increases in trading volume, as volume movements under Afalse@ announcements, that is when news reports of intervention are fiction, are less than half as large as when intervention is correctly reported.   These results should be read with a dose of caution as the sample size is small and the news data, when reporting intervention by the Federal Reserve, do not differentiate between intervention in the mark and in the yen.

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3 Despite the small sample sizes, testing for differences of mean trading volumes between announced and secret interventions yields t-statistics of 2.53 for the mark and 1.96 for the yen.
4 Mean trading volume on days preceding a secret intervention is 0.9252 for the mark and 1.0687 for the yen, clearly lower than on the day of the intervention, perhaps adding weight to the argument advanced by Goodhart and Hess and Hung.

6. Conclusion

We have presented clear evidence that foreign exchange intervention by the Federal Reserve has been correlated with a contemporaneous increase in trading volume. This effect is important even when volume is conditioned on contemporaneous or predicted volatility. The effect is also much stronger for announced than for secret intervention operations.

The results support the old saying that "it takes volume to move prices." What we certainly do not see in the data is an immediate price adjustment to a new post-intervention level, all without any volume effect. Instead, as market participants take time to digest the information content of the intervention, trading volume increases significantly. The increase in trading volume suggests that the information may impact traders in a heterogeneous fashion.

Without relying on price data, the evidence also reaffirms the importance of the announcement channel for intervention. Yet the relatively muted reaction to erroneous press reports of intervention operations is consistent with the idea that the trading process itself, and not just intervention news, carries information relevant to the price discovery process in these markets.

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