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Foreign Exchange Intervention: An Empirical Assessment

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16.1 Introduction

Can intervention policy effectively influence market expectatons of current and future foreign exchange rates? The conventional wisdom offers an unequivocal answer. Intervention in the foreign exchange market has little or no effect, except to the extent that it implies changes in countries' money supplies. In the latter case, intervention is just a particular variety of monetary policy. The conventional wisdom thus says that intervention does not offer the authorities an *independent* policy tool for influencing the foreign exchange market.

In the early 1980s, the belief that intervention was not an effective policy tool was widely shared among academic economists, central bankers, and market participants. In the first Reagan administration, the ineffectiveness of intervention was an article of faith, and the U.S. government accordingly refrained from buying or selling foreign exchange (with some minor exceptions). In 1985, however, attitudes at the U.S. Treasury shifted abruptly. The U.S. authorities began to intervene again in the markets, in collaboration with other country's central banks, most visibly as decided at the meeting of G-5 economic leaders at the Plaza Hotel in September of that year. Since that time, intervention has taken place regularly. Foreign exchange traders have taken note of it. They are observed to react to reports of intervention as vigorously as to any other sort of news. Most traders, and most involved central bankers, believe that this intervention has at times had important effects. We believe that the time is right for a reconsideration of the conventional wisdom as to the ineffectiveness of foreign exchange intervention.

In this chapter we examine the two possible channels through which intervention can influence the foreign exchange rate: the portfolio and the expectations channels. Intervention can influence exchange rates through the *portfolio channel* provided foreign and domestic bonds are considered imperfect substitutes in investors' portfolios. Intervention operations that, for example, increase the current supply of mark relative to dollar assets, which private investors are obliged to accept into their portfolios, will force a decrease in the relative price of deutsche mark assets.[1] Intervention can also influence exchange rates, regardless of whether foreign and domestic bonds are imperfect substitutes, through the *expectations channel*. The public information that central banks are intervening in support of a currency (or are planning to intervene in the future) may, under certain conditions, cause speculators to expect an increase in the price of that currency in the future. Speculators react to this information by buying the currency today, bringing about the change in the exchange rate today.

While some previous empirical studies of foreign exchange intervention operations have found evidence from daily data that central banks have had a statistically significant effect on exchange rates (Loopesko 1984; Dominguez 1990, 1992), the studies were not able to distinguish whether the effect was coming through the portfolio or the expectations channel. The goal of this study is to disentangle the influence of the two potential channels during the most recent experience with central bank intervention operations.

16.2 Intervention Policy in Practice

Intervention operations by central banks involve the purchase of foreign assets with domestic assets (or sale), which, if not *sterilized* will result in an increase (or decrease) in the domestic monetary base. For example, when the Fed intervenes against the dollar, the Fed's portfolio of foreign assets (typically deutsche mark and yen-denominated assets) increases while its dollar deposits decrease. At the same time, dollar deposits of commercial banks at the Fed increase. As a consequence, the U.S. monetary base (commercial bank deposits at the Fed plus currency in circulation) is increased. The Fed can sterilize this increase by selling the appropriate number of dollar-denominated assets in open-market operations.

The Federal Reserve Bank of New York reportedly fully and automatically sterilizes its intervention operations on a daily basis. In practice, the foreign exchange trading room immediately reports its dollar sales to the open market trading room, which then buys that many fewer bonds, so that the daily money supply is unaffected. The Bundesbank also claims to sterilize its foreign exchange intervention operations routinely as a technical matter. Nevertheless, the general view is that both banks have at times allowed intervention operations to influence monetary aggregates. The degree of monetary accommodation is, however, limited, to the extent that they both target money supply growth. In this chapter we do not concentrate on the distinction between sterilized and nonsterilized intervention. We study the intervention operations that actually took place between 1982 and 1988, regardless of whether they were sterilized.

Central banks have not routinely made daily intervention data available to the public. Quarterly data on monetary authorities' international reserves are available both from central bank publications and the International Monetary Fund's *International Financial Statistics.* Quarterly changes in these data have commonly been used by researchers as proxies for intervention flows.[2] These data, however, can differ significantly from actual official purchases of foreign exchange in the open market. The level of a country's reserves can change even if the central bank does not transact in the foreign exchange market. Reserves increase with interest accruals on offical portfolio holdings and fluctuate with valuation changes on existing nondollar reserves.

Apart from the fact that reserve data do not provide good approximations to official intervention activity, quarterly and monthly data obscure important daily information. Intervention operations are implemented on a minute-to-minute basis. Net daily intervention information at a minimum is necessary for study of intervention's effects. Data on daily official central bank purchases and sales in the foreign exchange market have rarely been made available to researchers outside the government.[3]

The U.S. Treasury has recently agreed to change its long-standing policy and has allowed the Board of Governors of the Federal Reserve System to make its daily intervention data publicly available, with a one-year lag. At this time none of the other G-7 central banks has a general policy of releasing its intervention data to the public. We are fortunate to have available for purposes of this study, in addition to the recently released Fed data, daily Bundesbank intervention data from 1982 through 1988.

Although contemporaneous intervention operations are not published on a daily basis by the central banks, daily intervention operations are frequently reported in newspapers and over the wire services. So although current official data are unavailable, there exist numerous unofficial sources of the data. How do traders and reporters learn about intervention operations? Although each central bank has its own particular set of practices, they generally undertake intervention directly with the foreign exchange desk of a large commercial bank. As with any other foreign exchange transaction, trades are officially anonymous. If the Fed decides to intervene in support of the dollar, the Fed trader can either call a broker or deal directly with another trader at a commercial bank to place an order for dollars. If the Fed would like the market to know the source of the dollar purchase, the Fed trader will call one of a number of selected commercial banks that the Fed traditionally does business with. Unless the Fed trader says otherwise, the bank trader will understand that not only does the Fed want to purchase dollars but that it would like the market to know this. This information is reportedly disseminated among traders in the market within minutes of the original Fed call.

Given the speed at which information flows in the foreign exchange market, more remarkable than the revelation of intervention operations are the occasions when operations are kept secret. In the U.S. case, the Fed is more likely to intervene secretly through the broker market, although it can also do so using a commercial bank with which it does not traditionally do business. The Fed also, on occasion, intervenes secretly through the major banks with which it traditionally does business. In any case, if the Fed trader says that the intervention operation is to remain secret, then the broker or bank trader has an incentive not to disclose the Fed's presence in the market if he or she ever wants to be privy to future intervention information and business.

What is the relative frequency of "secret" interventions? Secret interventions are not differentiated in central banks' official data, but one can roughly infer which operations were secret by comparing the official data with published reports of intervention activity in the financial press. Although traders may sometimes know that central banks are intervening without its showing up in the financial press, this relatively conservative accounting for reported intervention reveals that the bulk of recent intervention is not secret.[4] In the econometric analysis to follow, we include secret and reported intervention separately in order to determine whether the distinction is important.

16.3 A Two-Equation System: The Portfolio and Expectations Channels

The traditional theoretic explanation for how intervention operations influence exchange rates is based on the portfolio balance approach to exchange rate determination. The central assumption is that foreign and domestic bonds are imperfect substitutes for each other in investors' portfolios. Investors hold both foreign and domestic bonds in their portfolios and optimize a function of the mean and variance of their end-of-period wealth.[5] The monetary authority can influence the relative prices of foreign and domestic bonds by changing their relative supply in investors' portfolios. For example, if the Fed increases the relative supply of dollar-denominated bonds in the market, then investors will demand a dollar risk premium to compensate them for the risk that they bear holding the additional dollar assets.

The first equation in our two-equation system is a modified version of the traditional portfolio-balance model. (We introduced this form of the equation in Dominguez and Frankel 1993.) The main modification relative to the previous literature is that we assume that exchange rate expectations can be measured more precisely using survey data than by assuming rational expectations and using ex post changes in the exchange rate. Intuitively, the equation lets the expected risk premium on mark-denominated assets depend on the relative quantity of mark-denominated assets in investors' portfolios.

$$i^{DM}_{t,k} - i^{\$}_{t,k} + \Delta\hat{s}^{e}_{t,k} = \beta_0 + \beta_1 v_t + \beta_2 v_t x_t + u_{t,k} \tag{1}$$

where $i^{DM}_{t,k}$ is the k-period-ahead EuroDM interest rate, $i^{\$}_{t,k}$ is the k-period-ahead eurodollar interest rate, $\Delta\hat{s}^{e}_{t,k}$ is the expected change in the spot rate between period t and $t + k$ measured by the survey data, v_t is the daily variance of exchange rate changes over the preceding week, x_t is the share of mark-denominated assets in investors' portfolios, and the error term, $u_{t,k}$, reflects any measurement error in the data. If the sole (random) measurement error occurs in the survey data, OLS estimates of (1) will be appropriate. However, if the asset data are measured with error or if asset demands are given by the mean-variance specification *plus* an error term, then the regression will be subject to simultaneity bias and (1) should be estimated using instrumental variables. We do both.

The second equation in the two-equation system is our expectations equation. Regardless of whether the portfolio balance channel is operative, intervention operations may influence exchange rates if they provide relevant news to market participants.[6] The expectations equation therefore lets the change in investors' expectation of the future exchange rate be a function of past changes in the spot exchange rate and intervention policy news.

$$(\hat{s}^e_{t,k} - \hat{s}^e_{t-j,k}) = \alpha_0 + \alpha_1(s_t - s_{t-j}) + \alpha_2(s_t - \hat{s}^e_{t-j,k}) + \alpha_3 ANNOC_t + \alpha_4 REPINT_t + \alpha_5 SECINT_t + \varepsilon_t \qquad (2)$$

where $(\hat{s}^e_{t,k} - \hat{s}^e_{t-j,k})$ is the revision in the log of the MMS survey prediction of the k-period ahead dollar/mark spot rate from time $t - j$ to time t, s_{t-j} is the log of the spot rate on the day of the last MMS survey, $ANNOC_t$ and $REPINT_t$ are $(1, 0, -1)$ dummy variables that capture reports of exchange rate policy news since the last survey date, $SECINT_t$ is a $(1, 0, -1)$ dummy variable for nonreported intervention operations since the last survey date, and ε_t is the error term.[7]

Our specification of the expectation equation is general in that it allows for both extrapolative and adaptive expectations. At the four-week horizon, respondents have been observed to put negative weight on the lagged spot rate and more-than-unit weight on the contemporaneous spot rate, so that they are extrapolating the recent trend into the future to get their forecast.[8] Our extrapolative parameter is α_1. Bandwagon expectations are the special case $\alpha_1 > 0$ and $\alpha_2 = 1$. Previous work has also found evidence that respondents form their predictions adaptively, putting positive weight on the lagged survey prediction (Frankel and Froot 1987, reproduced here as chapter 13). Our speed-of-adaptation parameter is $(1 - \alpha_2)$. Adaptive expectations are the special case $\alpha_1 = 0$ and $\alpha_2 < 1$. Static expectations are the special case $\alpha_1 = 0$, $\alpha_2 = 1$. Expectations are stabilizing overall if $\alpha_1 + \alpha_2 < 1$, and destabilizing overall if $\alpha_1 + \alpha_2 > 1$.

We also include two news variables in our expectations equation in order to capture information appearing in the newspaper about changes in central banks' exchange rate policy since the last survey date. $ANNOC_t$ is set equal to $+1$ if there were central bank announcements in support of the dollar (including, for example, announcements of G-7 meetings to deal with dollar weakness), -1 if there were official announcements against the dollar, and 0 if there were no such announcements. $REPINT_t$ is set equal to $+1$ if there were reports of central bank intervention in support of the dollar, -1 if there were reports of intervention against the dollar, and 0 if there were no such reports. The fifth independent variable included in the regression is secret intervention, denoted $SECINT_t$. $SECINT_t$ is set equal to $+1$ if there were no reports of intervention when a central bank in fact intervened in support of the dollar, -1 if interventions against the dollar were not reported, and 0 otherwise. We expect the two news variables, $ANNOC_t$ and $REPINT_t$ to have a negative effect on expectations of the future dollar/mark rate. If nonreported intervention is truly secret, we expect the coefficient on $SECINT_t$, α_5, to be zero.

The survey data used in both the portfolio balance and expectations equations are four-week-ahead survey forecasts of the mark-dollar exchange rate conducted by Money Market Services, International, for the period October 24, 1984 to December 30, 1988.[9] Unlike some other surveys, it is conducted on a weekly basis (since July 1985; before that it was conducted every two weeks). In addition, we report results for an earlier period November 17, 1982, to October 10, 1984, when the survey pertained to three-month ahead forecasts. One might expect that intervention would have a greater effect in the later period, since the Reagan administration's firm commitment to free-floating began to waver when Donald Regan and Beryl Sprinkel were succeeded at the Treasury by James Baker and Richard Darman in January 1985, and when the Plaza Agreement followed in September.

The intervention data series measure consolidated daily official foreign exchange transactions in millions of dollars at current market values. Positive values denote purchases of dollars and negative values denote official dollar sales. The Fed data distinguish between interventions against the mark and the yen and exclude so-called passive intervention operations. Passive interventions are Fed purchases and sales of foreign currency with customers who would otherwise have dealt with market agents.[10] The Bundesbank data exclude nondiscretionary interventions required by rules of the European Monetary System.

The daily intervention data provided by the central banks measure official net purchases or sales of dollars in the foreign exchange market. Central bank interest payments and receipts on reserve assets are not included in the data. Intervention is measured in three ways in these regressions. *One-day* intervention is Fed and Bundesbank purchases of dollars on the day before the survey. *Two-week* or *one-week* intervention is cumulated between survey dates, so that it measures total Fed and Bundesbank dollar purchases since the last survey. *Cumulative* intervention is cumulated from the beginning of the sample period and therefore measures the relative stock supplies of outside assets denominated in dollar and mark currencies.

Equations (1) and (2) make up our two-equation system. The two endogenous variables are the current period spot rate and survey expectation of the future spot rate. We are able to deal with the potential simultaneity problems in both equations by using the exogenous variables from each equation as instruments for the other equation. The instruments for equation (1) include last period's spot exchange rate, s_{t-j}, last period's survey expectation of the future spot rate, $\hat{s}^e_{t-j,k}$, and the news variables, $ANNOC_t$ and $REPINT_t$, from equation (2). The instruments for equation (2) include the variance of spot changes since the last survey date, v_t, and the total quantity of marks sold in foreign exchange intervention (measured in marks), x_t, from equation (1).

16.4 The Estimation Results

Table 16.1 presents the expectations equation regression results for the early sample period. News reports appear to have had no effect on expecta-

Table 16.1

Sample: November 1982–October 1984

$(\hat{s}^e_{t,k} - \hat{s}^e_{t-j,k}) = \alpha_0 + \alpha_1(s_t - s_{t-j}) + \alpha_2(s_t - \hat{s}^e_{t-j,k}) + \alpha_3 ANNOC_t + \alpha_4 REPINT_t + \alpha_5 SECINT_t + \varepsilon_t$

Biweekly three-month-ahead survey expectation equation (Obs = 54, $k = 90$, $j = 14$) instruments: v_t, IDM_t

	One-day[a]		Two-week[b]		Cumulative[c]	
α_0	0.005	(0.006)	0.006	(0.006)	0.008	(0.008)
α_1	0.414	(0.400)	0.328	(0.367)	−0.069	(0.609)
α_2	0.406	(0.210)[†]	0.420	(0.217)[†]	0.432	(0.279)
α_3	−0.002	(0.008)	−0.002	(0.008)	−0.005	(0.010)
α_4	0.002	(0.007)	0.003	(0.006)	0.008	(0.009)
α_5	−0.001	(0.004)	−0.001	(0.004)	0.003	(0.006)
$\chi^2(1)$	7.990**		7.177**		4.123*	
$\chi^2(2)$	7.822**		9.272**		1.984	
D.W.	2.09		2.05		1.90	
R^2	0.72		0.70		0.51	

a. Intervention instrumental variable (*IDM*) is measured at the end-of-day prior to the survey.
b. Intervention instrumental variable is an accumulated measure between survey forecasts.
c. Intervention instrumental variable is an accumulated measure from the beginning of the sample period.
Note: Standard errors are in parentheses. † denotes significance at the 90% level; * denotes significance at the 95% level; ** denotes significance at the 99% level.
The $\chi^2(1)$ statistic pertains to the hypothesis that $\alpha_2 = 1$ (expectations are not adaptive); and $\chi^2(2)$ pertains to the hypothesis that $\alpha_1 = \alpha_2 = 0$ (expectations are not extrapolative, but are completely adaptive).

tions in the early period 1982 through 1984. However, the instrumental variable estimates for the same regression over the 1985–1988 subperiod, presented in table 16.2, indicate a marked change in regime. The coefficients on the news variables appear with the correct sign and are statistically significant in all the regressions for the latter sample: newspaper reports of exchange rate policy announcements and central bank intervention in support of the dollar tend to lower expectations of the future dollar/mark exchange rate. The average effect of reported intervention on the one-month ahead expectations of the dollar/mark exchange rate ranged between .4 and .6 percent. The effect of other official announcements was twice as large, ranging between .9 and 1.1 percent.

In table 16.2 the coefficient on the lagged spot rate, $-\alpha_1$, and the coefficient on the lagged expectation, $(1 - \alpha_2)$, are each statistically different from both zero and one. In other words, there is evidence of extra-

Table 16.2
Sample: October 1984–December 1988
$(\hat{s}^e_{t,k} - \hat{s}^e_{t-j,k}) = \alpha_0 + \alpha_1(s_t - s_{t-j}) + \alpha_2(s_t - \hat{s}^e_{t-j,k}) + \alpha_3 ANNOC_t + \alpha_4 REPINT_t + \alpha_5 SECINT_t + \varepsilon_t$

Weekly one-month-ahead survey expectation equation (Obs = 186, $k = 30$, $j = 7$) instruments: v_t, IDM_t

	One-day[a]		One-week[b]		Cumulative[c]	
α_0	0.005	(0.001)**	0.006	(0.001)**	0.005	(0.001)**
α_1	0.394	(0.194)*	0.442	(0.219)*	0.146	(0.253)
α_2	0.559	(0.116)**	0.626	(0.116)**	0.478	(0.134)**
α_3	−0.009	(0.002)**	−0.009	(0.002)**	−0.011	(0.003)**
α_4	−0.005	(0.002)**	−0.004	(0.002)*	−0.006	(0.002)**
α_5	0.005	(0.003)	0.005	(0.003)	0.007	(0.003)*
$\chi^2(1)$	14.362**		10.379**		15.144**	
$\chi^2(2)$	17.821**		18.724**		6.599**	
D.W.	2.24		2.23		2.10	
R^2	0.67		0.67		0.61	

a. Intervention instrumental variable (*IDM*) is measured at the end-of-day prior to the survey.
b. Intervention instrumental variable is an accumulated measure between survey forecasts.
c. Intervention instrumental variable is an accumulated measure from the beginning of the sample period.
Note: Standard errors are in parentheses. * denotes significance at the 95% level; ** denotes significance at the 99% level. The $\chi^2(1)$ statistic pertains to the hypothesis that $\alpha_2 = 1$ (expectations are not adaptive); and $\chi^2(2)$ pertains to the hypothesis that $\alpha_1 = \alpha_2 = 0$ (expectations are not extrapolative, but are completely adaptive).

polative behavior *and* gradual adaptation. Overall, expectations are neither stabilizing nor destabilizing.

Tables 16.3 and 16.4 present the portfolio equation regression results. The intervention variable (defined as x_t in the text) is measured in millions of dollars in these tables. This approach allows the estimated coefficient to determine the denominator of the portfolio shares and is preferred, to the extent one lacks faith in the reliability of measurements of aggregate wealth.[11] We disaggregate the intervention variable by including Fed and Bundesbank intervention separately. The three separate sets of regressions, therefore, include intervention measured as the sum of Bundesbank and Fed intervention, intervention by the Bundesbank, and intervention by the Fed.

Table 16.4 presents the instrumental variable regressions of equation (1) over the latter subperiod, October 1984 to December 1988. The coefficient on intervention is generally statistically significant, regardless of how it is measured. This result implies that intervention, even if sterilized, had an effect. If mark and dollar assets were perfect substitutes, then the coefficient should have been zero: changes in asset supplies would have no effect on the risk premium.

In order to check that the results reported in table 16.4 are robust, we reestimated equation (1), excluding outliers and the variance constraint. In order to examine the influence of outliers on the results, we searched for regression residuals from equation (1) that were greater than 2.5 times the standard error of the regression estimate. Over the full sample period, two observations met the criterion: September 25, 1985 (the second trading day after the Plaza Accord) and March 5, 1986. Table 16.5 presents regression estimates of equation (1) excluding the two outlying observations over the latter subperiod and including the intervention variable as a percent of wealth, rather than in millions of dollars. If we control for the definition of intervention in the regression, the intervention coefficient estimates excluding the two outliers are virtually identical to those reported in table 16.4. The coefficient estimates on the variance terms, however, are no longer statistically significant except when intervention is cumulated from the beginning of the sample period. In a second set of tests presented in table 16.6 we examine the sensitivity of the reported results to the mean-variance specification by reestimating (1) without constraining the variance and intervention to enter multiplicatively. The estimated coefficients on the intervention variables are qualitatively identical (in terms of statistical significance) to those reported in tables 16.4 and 16.5.

Table 16.3
Sample: November 1982–October 1984
$i^{DM}_{t,k} - i^{\$}_{t,k} + \Delta\hat{s}^{e}_{t,k} = \beta_0 + \beta_1 v_t + \beta_2 v_t I_t + u_{t,k}$

Biweekly three-month-ahead risk premium equation (Obs = 55, $k = 90$, $j = 14$, intervention expressed in millions of \$) instruments: s_{t-j}, $\hat{s}^{e}_{t-j,k}$, $ANNOC_t$, $REPINT_t$

	One-day[a]		Two-week[b]		Cumulative[c]	
I I_t *includes Fed and Bundesbank intervention*						
β_0	0.009	(0.004)*	0.009	(0.004)*	0.005	(0.003)†
β_1	−28.032	(57.433)	−38.212	(60.749)	372.170	(109.322)**
β_2	0.279	(0.706)	0.012	(0.061)	0.043	(0.009)**
ρ	0.625	(0.197)**	0.621	(0.204)**	0.266	(0.369)
D.W.	2.16		2.15		1.94	
R^2	0.41		0.41		0.39	
II I_t *includes only Bundesbank intervention*						
β_0	0.009	(0.004)*	0.009	(0.004)*	0.005	(0.003)†
β_1	−55.220	(63.241)	−37.319	(61.343)	371.305	(107.605)**
β_2	−0.784	(1.593)	0.003	(0.066)	0.045	(0.009)**
ρ	0.644	(0.189)**	0.632	(0.198)**	0.251	(0.411)
D.W.	2.15		2.16		1.94	
R^2	0.41		0.42		0.40	
III I_t *includes only Fed intervention*						
β_0	0.009	(0.004)*	0.009	(0.004)*	0.006	(0.004)
β_1	−27.264	(55.588)	−45.193	(48.008)	369.001	(168.774)*
β_2	1.029	(1.762)	−0.497	(0.647)	0.937	(0.365)*
ρ	0.615	(0.203)**	0.645	(0.191)**	0.544	(0.362)
D.W.	2.17		2.16		2.06	
R^2	0.41		0.39		0.31	

a. Intervention variable is measured at the end-of-day prior to the survey.
b. Intervention variable is an accumulated measure between survey forecasts.
c. Intervention variable is an accumulated measure from the beginning of the sample period.
Note: Standard errors are in parentheses. † denotes significance at the 90% level; ** denotes significance at the 99% level. ρ is the estimated first lag correlation coefficient.

Table 16.4
Sample: October 1984–December 1988
$i^{DM}_{t,k} - i^{\$}_{t,k} + \Delta\hat{s}^{e}_{t,k} = \beta_0 + \beta_1 v_t + \beta_2 v_t I_t + u_{t,k}$

Weekly one-month-ahead risk premium equation (Obs = 185, $k = 30$, $j = 7$, intervention expressed in millions of $) instruments: s_{t-j}, $\hat{s}^{e}_{t-j,k}$, $ANNOC_t$, $REPINT_t$

	One-day[a]		One-week[b]		Cumulative[c]	
I $\mathbf{I}_t$ *includes Fed and Bundesbank intervention*						
β_0	0.001	(0.001)	0.002	(0.001)	0.002	(0.002)
β_1	53.851	(17.355)**	39.501	(13.766)**	217.216	(104.010)*
β_2	0.308	(0.128)*	0.067	(0.030)*	0.009	(0.005)†
ρ	0.307	(0.194)	0.344	(0.202)†	0.449	(0.173)**
D.W.	2.12		2.13		2.22	
R^2	0.08		0.14		0.11	
II $\mathbf{I}_t$ *includes only Bundesbank intervention*						
β_0	0.002	(0.001)	0.002	(0.001)†	0.002	(0.002)
β_1	38.803	(14.283)**	32.562	(13.103)*	178.043	(94.692)†
β_2	0.328	(0.184)†	0.083	(0.053)	0.008	(0.005)
ρ	0.343	(0.176)†	0.347	(0.191)†	0.397	(0.068)**
D.W.	2.15		2.15		2.18	
R^2	0.13		0.15		0.16	
III $\mathbf{I}_t$ *includes only Fed intervention*						
β_0	0.001	(0.002)	0.002	(0.001)	0.002	(0.002)
β_1	49.716	(17.780)**	39.809	(14.076)**	64.535	(20.422)**
β_2	0.410	(0.222)†	0.103	(0.055)†	0.018	(0.008)*
ρ	0.335	(0.176)†	0.361	(0.190)†	0.483	(0.177)**
D.W.	2.14		2.15		2.25	
R^2	0.09		0.14		0.05	

a. Intervention variable is measured at the end-of-day prior to the survey.
b. Intervention variable is an accumulated measure between survey forecasts.
c. Intervention variable is an accumulated measure from the beginning of the sample period.
Note: Standard errors are in parentheses. † denotes significance at the 90% level; ** denotes significance at the 99% level. ρ is the estimated first lag correlation coefficient.

Table 16.5
Sample: October 1984–December 1988
(omitting outlying observations on 9/25/85 and 3/5/86)
$i^{DM}_{t,k} - i^{\$}_{t,k} + \Delta \hat{s}^{e}_{t,k} = \beta_0 + \beta_1 v_t + \beta_2 v_t I_t + u_{t,k}$

Weekly one-month-ahead risk premium equation (Obs = 183, $k = 30$, $j = 7$, intervention expressed as prcent of wealth) instruments: s_{t-j}, $\hat{s}^{e}_{t-j,k}$, $ANNOC_t$, $REPINT_t$

	One-day[a]		One-week[b]		Cumulative[c]	
I $\mathbf{I}_t$ *includes Fed and Bundesbank intervention*						
β_0	0.003	(0.001)*	0.003	(0.001)*	0.003	(0.002)†
β_1	19.728	(14.734)	18.039	(14.675)	217.351	(71.927)**
β_2	7222.415	(2229.645)**	1565.290	(552.027)**	193.954	(67.694)**
ρ	0.386	(0.177)*	0.393	(0.197)*	0.478	(0.198)*
D.W.	2.20		2.17		2.23	
R^2	0.19		0.20		0.19	
II $\mathbf{I}_t$ *includes only Bundesbank intervention*						
β_0	0.004	(0.002)*	0.004	(0.001)*	0.003	(0.001)*
β_1	16.721	(14.690)	16.744	(14.682)	450.834	(114.997)**
β_2	6867.251	(2882.011)*	1926.778	(915.987)*	459.885	(120.435)**
ρ	0.402	(0.165)*	0.389	(0.188)*	0.429	(0.362)
D.W.	2.22		2.18		2.18	
R^2	0.20		0.19		0.21	
III $\mathbf{I}_t$ *includes only Fed intervention*						
β_0	0.003	(0.002)†	0.003	(0.001)*	0.003	(0.002)
β_1	19.598	(14.952)	17.108	(14.694)	51.374	(22.239)*
β_2	11792.140	(4571.997)**	2557.322	(1059.437)*	372.542	(165.706)*
ρ	0.409	(0.162)*	0.422	(0.180)*	0.533	(0.172)**
D.W.	2.21		2.20		2.28	
R^2	0.18		0.20		0.13	

a. Intervention variable is measured at the end-of-day prior to the survey.
b. Intervention variable is an accumulated measure between survey forecasts.
c. Intervention variable is an accumulated measure from the beginning of the sample period.
Note: Standard errors are in parentheses. † denotes significance at the 90% level; * denotes significance at the 95% level; ** denotes significance at the 99% level. The coefficient on $v_t I_t$ (β_2) and its corresponding standard error are divided by 100 for readability. ρ is the estimated first lag correlation coefficient.

Table 16.6
Sample: October 1984–December 1988
$i_{t,k}^{DM} - i_{t,k}^{\$} + \Delta\hat{s}_{t,k}^{e} = \beta_0 + \beta_1 v_t + \beta_2 v_t I_t + u_{t,k}$

Weekly one-month-ahead unconstrained risk premium equation
(Obs = 185, $k = 30$, $j = 7$, intervention expressed as percent of wealth)
instruments: s_{t-j}, $\hat{s}_{t-j,k}^{e}$, $ANNOC_t$, $REPINT_t$

	One-day[a]		One-week[b]		Cumulative[c]	
I $\mathbf{I}_t$ *includes Fed and Bundesbank intervention*						
β_0	0.002	(0.001)†	0.003	(0.001)*	0.017	(0.006)**
β_1	30.639	(12.448)*	28.803	(12.295)*	38.850	(13.519)**
β_2	43.774	(12.632)**	12.325	(3.725)**	1.641	(0.574)**
ρ	0.319	(0.196)	0.288	(0.228)	0.459	(0.232)*
D.W.	2.14		2.12		2.24	
R^2	0.15		0.16		0.10	
II $\mathbf{I}_t$ *includes only Bundesbank intervention*						
β_0	0.003	(0.001)†	0.003	(0.001)*	0.028	(0.007)**
β_1	28.118	(12.459)*	26.513	(12.289)*	38.876	(13.124)**
β_2	39.366	(15.466)*	16.161	(6.028)**	2.876	(0.848)**
ρ	0.342	(0.176)†	0.299	(0.208)	0.402	(0.387)
D.W.	2.16		2.12		2.19	
R^2	0.16		0.16		0.13	
III $\mathbf{I}_t$ *includes only Fed intervention*						
β_0	0.002	(0.001)	0.002	(0.001)	0.004	(0.002)†
β_1	32.935	(12.714)**	30.822	(12.532)*	38.944	(14.106)**
β_2	82.379	(28.492)**	17.366	(6.612)**	3.679	(1.651)*
ρ	0.347	(0.179)†	0.334	(0.195)†	0.537	(0.192)**
D.W.	2.15		2.15		2.32	
R^2	0.14		0.15		0.05	

a. Intervention variable is measured at the end-of-day prior to the survey.
b. Intervention variable is an accumulated measure between survey forecasts.
c. Intervention variable is an accumulated measure from the beginning of the sample period.
Note: Standard errors are in parentheses. † denotes significance at the 90% level; * denotes significance at the 95% level; ** denotes significance at the 99% level. ρ is the estimated first lag correlation coefficient.

16.5 A Summary of the Quantitative Effects

Our two-equation system estimates indicate that official announcements about exchange rate policy and reports of intervention influence exchange rate expectations, and intervention operations influence the risk premium. In this section, we make use of some of the parameter estimates from our regression analyses as an example to calculate the effect of intervention on the dollar/mark exchange rate. We assume in these calculations that interest rates in the United States and Germany are held constant. If interest rates were allowed to vary, then the effects in a general portfolio-balance model might be either smaller or larger than those reported here. Sterilized intervention in support of the dollar, for example, might drive down dollar interest rates, reducing the demand for dollar assets and thereby mitigating the effect on the exchange rate.

First, consider the effect of intervention on the exchange rate if it is not known publicly. We begin with the baseline case where expectations are assumed to be neither extrapolative nor adaptive. Under these assumptions, the intervention has no effect at all on the risk premium. If the risk premium does not change, then equation (1) indicates that x_t does not change.

The portfolio share that is allocated to mark assets, x_t, is defined as S_tM_t/W_t, where S_t is the spot mark-dollar exchange rate, M_t is the total quantity of mark assets in investors' portfolios (denominated in marks), and W_t is total wealth (denominated in dollars). Analogously, the portfolio share that is allocated to dollar assets, $1 - x_t$, is defined as D_t/W_t where D_t is the total quantity of dollar assets held in investors' portfolios and $S_tM_t + D_t = W_t$. S_t, the spot exchange rate, is thus equal to:

$$S_t = \frac{D_t}{M_t}\frac{x_t}{1 - x_t}. \tag{3}$$

From this expression for S_t, it is evident that the effect of intervention on the exchange rate is in proportion to the supply of mark assets in investors' portfolios. What is the effect of 100 million dollars of intervention? If we are thinking of the special case where only nonsterilized intervention matters, then the definition of M_t is relatively clear: total reserve money supplied to the banking system by the Bundesbank, which, as of the end of 1988, was \$124.19 billion.[12] Thus the effect is only .081 percent. If we are thinking of sterilized intervention, then the effect of 100 million dollars of intervention will be even smaller, because M_t is the total supply of mark-denominated bonds, rather than just mark money. It should be emphasized that these small magnitudes derive solely from the small size of intervention relative to the relevant denominators and not from any parameters that we have estimated. But it is worth recalling that this effect, even if small, is nonetheless not zero, according to our rejection of perfect substitutability between mark and dollar bonds.

To get large effects on the exchange rate, we need the public to hear the news of the intervention. Our second experiment considers the effect of such information in isolation, as reflected in the coefficient on the reported intervention dummy variable, even if such intervention is in fact not taking place. If intervention actually takes place and is publicly reported, then its total effect would be the sum of the (small) effect reported in the preceding paragraph plus the (much larger) effect reported in the next paragraph. Under our baseline case (no change in interest rates and no extrapolative or adaptive expectations), the risk premium simply changes by the coefficient of $REPINT_t$ in the expectation equation. Such a change in the risk premium will have a large effect on the demand for mark-versus-dollar assets.

In order to calculate the effect of a report of intervention on the exchange rate we need to return to equation (3). The log form of equation (3) is:

$$\log S_t = \log\left(\frac{D_t}{M_t}\right) + \log(x_t) - \log(1 - x_t). \tag{4}$$

The derivative of the log of the spot exchange rate with respect to reported intervention can be calculated using (4) and the knowledge that x_t is a function of the risk premium, rp_t, which in turn is a function of expected depreciation, $\Delta\hat{s}^e_{t,k}$, which in turn is a function of the news variables $REPINT_t$ and $ANNOC_t$.

$$\frac{d\log S_t}{dREPINT_t} = \left[\frac{1}{x_t} + \frac{1}{1 - x_t}\right]\frac{dx_t}{drp_t}\,\frac{drp_t}{dREPINT_t}. \tag{5}$$

The derivative of x_t with respect to the risk premium is $(v_t\beta_2)^{-1}$ from equation (1). If we rearrange equations (1) and (2), hold interest rates constant and set $\alpha_1 = 1$ and $\alpha_2 = 0$, we see that the derivative of the risk premium with respect to reported intervention is equal to the derivative of the expected depreciation with respect to reported intervention, which is α_4 from equation (2). As an example, if we take $x = .5$ and take our parameter estimates from I_t defined as cumulative intervention, the effect of an intervention report on the exchange rate is 2.7 percent.[13] If we measure x_t at the end of the sample period (.112),[14] the effect is approximately twice as large. If we take β_2 estimates from one-day or one-week intervention equations, the effect is much smaller.

The expectations effect of news on the exchange rate seems high. One's intuition that the effect should, in reality, be smaller can easily be fit into any of several categories. First, it is possible, even if we are talking about intervention that is sterilized in the sense that there is no change in the money supply, that the interest rates will absorb some of the impact of the decreased demand for mark assets (the German interest rate rising and the U.S. interest rate falling), so that the depreciation of the mark will be smaller. One would need to specify a complete portfolio-balance model to answer how big the changes in the interest rates would be. But the effect on the nominal interest differential need not be large to damp significantly the reported effect on the spot rate.

Second, if one wishes to depart from the baseline case to consider the possibility of extrapolative expectations, then the effects reported above obtain only in the long-run equilibrium in which $s_t - s_{t-1}$ is zero. The short-run impact effect could be smaller.[15] For some readers an intuitively appealing implication of extrapolative expectations is that, after the first-week impact of the news, market forecasters react further to the observed change in the exchange rate by jumping on the bandwagon, so that the effect grows in subsequent weeks. Others may prefer to believe that expectations are regressive rather than extrapolative or that newspaper reports or other random disturbances to the level of the spot rate, to the extent that they are not confirmed subsequently by actual observed changes in macroeconomic fundamentals, will gradually lose their effect on the spot rate as time passes, and that this "unwinding factor" is not adequately captured in our equations. This last possibility would constitute a third factor that could reduce the effect on the spot rate in long-run equilibrium below that reported above.[16]

Our own inclination is to believe that expectations only tend to be extrapolative in occasional periods: speculative bubble environments, when the foreign exchange market loses its moorings and forecasters forget about fundamentals. Of course, these are precisely the periods in which central bankers might be most interested in using the tool of intervention.[17]

The last circumstance in which the effect on the spot rate would be less than that estimated here is if the event occurs during a period when the variance is higher than it is on average. Again, this might be precisely the sort of period in which central bankers would be most interested in using intervention as a short-term tool, to smooth disorderly markets.[18]

Our results cannot be viewed as definitive. Nevertheless, to sum up, the findings for the dollar/mark rate during our mid-1980s sample period are generally favorable for the effectiveness of intervention. There appear to be statistically significant effects both through the expectations channel and through the portfolio channel. The quantitative effects can vary, depending both on the particular estimates chosen for the key parameters and on the precise experiment that one wishes to consider. But we hope that the statistical significance of the effects that we find will contribute to a reevaluation of the conventional wisdom as to the ineffectiveness of intervention.

Appendix 16A: Variable Definitions and Data Sources

s_t	log of the \$/DM spot exchange rate at time t (source: DRI)
$\hat{s}^e_{t,k}$	log of Money Market Services median k-period-ahead expectation for the \$/DM rate at time t (source: MMS)
v_t	daily variance of \$/DM exchange rate changes over the preceding week
$i^{DM}_{t,k}$	Euro-DM k-period-ahead interest rate at time t (source: DRI)
$i^{\$}_{t,k}$	Euro-\$ k-period-ahead interest rate at time t (source: DRI)
I_t	central bank intervention, in millions of \$, known at time t[19] (sources: Fed and Bundesbank)
IDM_t	central bank intervention, in millions of DM, known at time t
$ANNOC_t$	+1 for official central bank announcements in support of the dollar since the last MMS survey date (source: newspapers[20]) −1 for official central bank announcements against the dollar since the last MMS survey date (source: newspapers) 0 for no relevant central bank announcements (except intervention)
$REPINT_t$	+1 for reported central bank intervention in support of the dollar since the last MMS survey date (source: newspapers) −1 for reported central bank intervention against the dollar since the last MMS survey date (source: newspapers) 0 for no reports of central bank intervention
$SECINT_t$	+1 if $I_t > 0$ and $REPINT_t = 0$ −1 if $I_t < 0$ and $REPINT_t = 0$ 0 otherwise

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