Central-Bank Intervention: Recent Literature, Continuing Controversy

by Owen F. Humpage

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Introduction

Since the inception of floating exchange rates nearly 20 years ago, governments have refused to give private markets free reign in determining the exchange values of their currencies. They have instead bought and sold foreign exchange in an attempt to influence the path of exchange rates or to reduce the volatility of exchange rates around that path. Nearly all governments contend that intervention is effective. Less certain—and fundamental in the continuing debate about intervention—is whether central banks can separate intervention from their overall monetary policies and have it remain an effective tool for influencing exchange rates.

If nations could successfully intervene without altering their monetary bases (sterilized intervention), then any country could manipulate its exchange rate without jeopardizing price stability, and any group of countries could coordinate its exchange-rate goals without sacrificing monetary sovereignty. If, instead, intervention is effective only when it induces a change in the monetary base or, possibly, when it signals future changes in monetary policies, then one must weigh the merits of attempting to influence exchange rates against the potential conflicts with domestic monetary policy objectives.

This paper surveys theoretical arguments and recent empirical literature bearing on this controversy. Two conclusions emerge: First, the recent literature offers some threads of evidence to support the view that intervention can sometimes influence market expectations and exchange rates. Nevertheless, these threads cannot be woven into a strong fabric of support for an active intervention policy, whereby central banks acquire huge portfolios, enter markets frequently, and undertake large, sterilized transactions. I find little evidence to support interventions of the type that the Group of Three Countries (G3)—West Germany, Japan, and the United States—undertook in late 1985, mid-1987, and 1989. Instead, the evidence suggests that under rather specific and unusual circumstances, sterilized intervention might temporarily influence exchange rates. Second, I find that exchange-rate intervention and price stability are not always incompatible, but they can be difficult to combine.

BOX 1

Sterilized and Nonsterilized Intervention

Monetary Authority's Balance Sheet

Assets	Liabilities
Net Foreign Assets	**Monetary Base**
Gold	Currency held by the public
Foreign exchange	Reserves
SDR	
Net position in IMF	
Domestic Assets	**Net Worth**
Government securities	
Loans to depository institutions	
Other	

The table above, which presents a stylized balance sheet for a hypothetical central bank, helps to illustrate the important distinction between sterilized and nonsterilized intervention. On the asset side of the ledger are net foreign assets (*NFA*), which consist of foreign reserves less liabilities to foreign officials, and domestic assets (*DA*), which consist primarily of loans to depository institutions and government securities. On the liability side of the ledger is the monetary base (*MB*). Assume that net worth is zero. Then both sides of the ledger will balance such that

$$NFA + DA = MB.$$

When a central bank intervenes in the foreign exchange market, it buys or sells foreign assets (*NFA*) in exchange for its domestic currency. The transaction increases the nation's monetary base, in keeping with the balance-sheet identity:

$$\Delta MB = \Delta NFA.$$

The change in the monetary base leads to a multiple expansion of the nation's money stock. This intervention is nonsterilized. Notice that it is similar to a domestic open-market transaction, except that it is undertaken with foreign exchange rather than with government securities.

The monetary authority can offset the impact of this intervention on the monetary base, or sterilize it, by undertaking offsetting transactions with other assets. Typically, central banks do this by selling government securities or by altering their lending to depository institutions until

$$\Delta MB = -\Delta DA.$$

If nations undertake intervention in close consultation, all governments could sterilize intervention in a similar manner.

The process of intervening, especially if that intervention is completely sterilized, will change the mix of foreign and domestic assets held by central banks. Correspondingly, sterilized central-bank intervention must change the mix of domestic and foreign governmental assets held by the public.

I. Monetary Policy and Intervention

From an academic perspective, the distinction between sterilized and nonsterilized intervention, upon which this controversy ultimately focuses, is straightforward, if not trivial. A central bank can easily stabilize its monetary base, despite any exchange-market activity, by undertaking countervailing transactions through open-market operations or through other conventional monetary policy instruments. Nonsterilized intervention involves no monetary offset and differs from a typical monetary policy transaction only in that a central bank alters its monetary base through a change in its foreign asset holdings rather than through a change in its domestic asset holdings (see box 1).

Despite its academic clarity, the practical distinction between sterilized and nonsterilized intervention is neither obvious nor simple. Most countries, including the United States, claim to sterilize their intervention, but do so in the sense of not allowing their foreign exchange transactions to interfere with monetary policy goals, which may include an exchange-rate objective. When these countries factor exchange-rate targets into their monetary policy objectives, they need not offset their intervention activities currency unit per currency unit to conform with this definition of sterilized intervention. Although U.S. officials and many others accept this definition of sterilized intervention, it seems to violate the spirit of the term, because it no longer offers a means of pursuing independent exchange-rate and domestic monetary policy objectives. Throughout this paper, I define intervention as central-bank actions to influence exchange rates, and I define monetary policy only in terms of domestic price stability.

None of the G3 countries completely divorces its intervention activities from its domestic monetary policies; these countries either occasionally adopt exchange-rate targets for their monetary policies, or they do not always completely sterilize their intervention. Pauls (1990, p. 901), for example, observes, "During times when the dollar's exchange value raised particular concern — 1977–79, 1984–85, and 1987 — it became a significant factor in Federal Reserve decisions regarding monetary policy." Furlong (1989) also shows that FOMC directives from 1986 through 1988 gave substantial weight to exchange rates. Although the United States routinely sterilizes its intervention, in accordance with the definition mentioned in the previous paragraph, it does

not completely separate its exchange-rate and monetary policies.

In a recent article, Neumann and von Hagen (1991) show that the German Bundesbank has often permitted deviations between actual money growth and targeted money growth because of exchange-rate considerations. Following von Hagen (1989), they also argue that when the mark is strong against both the dollar and the Exchange-Rate-Mechanism currencies, the Bundesbank does not permanently sterilize its intervention.[1]

The situation is similar for Japan. Hutchison (1988) indicates that the Bank of Japan factored an exchange-rate objective into its monetary policy decisions between 1978 and 1985, and Takagi (1989) shows that since late 1985, the Bank of Japan has allowed intervention to affect its monetary base.

II. Intervention and Exchange Rates

Economic theory suggests three linkages between intervention and exchange rates, which differ in their implications for sterilized intervention. Only one of these, the portfolio-adjustment channel, allows completely sterilized intervention to affect exchange rates permanently. Through a second mechanism, the signaling channel, intervention can influence market expectations and, thereby, exchange rates. The literature presents two versions of signaling. According to the first, intervention might supplement monetary policy by strengthening a central bank's credibility with respect to its stated monetary policy objectives. According to the second version, if exchange markets are not informationally efficient, intervention that improves the flow of information might influence exchange rates. Central banks could sterilize such intervention, but the effect would be temporary. A third channel, the monetary channel, views intervention as a type of open-market operation that, by definition, does not admit even temporary sterilization.

Portfolio Adjustment

By sterilizing intervention through open-market transactions, central banks change the relative supplies of publicly held government debt. A sterilized intervention to depreciate the dollar, for example, increases the amount of publicly held U.S. Treasury securities. Under certain circumstances, such changes in asset stocks affect exchange rates.

According to the asset-market approach to exchange-rate determination, risk-averse investors diversify their portfolios across assets denominated in different currencies.[2] At equilibrium, the expected nominal returns on domestic and foreign assets are equal. Equation (1) represents this in logarithmic form:

$$(1) \quad r_t = r_t^* - f_t + s_t,$$

where r_t and r_t^* are one-period domestic and foreign interest rates, respectively; f_t is the current forward exchange rate for delivery one period ahead; and s_t is the current spot exchange rate (foreign currency units per domestic currency units).

If investors form their expectations rationally and view domestic and foreign assets as perfect substitutes, the forward exchange rate will equal the expected future exchange rate. If, however, investors believe that domestic and foreign assets have different risk characteristics, then the forward exchange rate will differ from the future expected exchange rate by a risk premium. Let

$$(2) \quad f_t = E(s_{t+1}) - \theta,$$

which defines the domestic asset as the relatively risky asset. Under the assumption that domestic and foreign assets are imperfect substitutes, the equilibrium condition becomes

$$(3) \quad r_t = r_t^* - E(s_{t+1}) + s_t + \theta.$$

As equation (3) indicates, investors compare the return on a domestic asset with the return on a foreign asset, which includes the interest earnings, the expected change in the exchange rate over the holding period, and a risk premium, θ. Rearranging equation (3), one can express the risk premium in terms of the interest-rate differential and the expected change in the exchange rate:

$$(4) \quad \theta = (r_t - r_t^*) + [E(s_{t+1}) - s_t].$$

Although economists lack a widely accepted theoretical model of the risk premium, most express it, among other things, as a positive

■ 1 See also Kahn and Jacobson (1989) and, for a somewhat different opinion, Obstfeld (1983).

■ 2 Edison (1990), Humpage (1986), Obstfeld (1988), and Weber (1986) discuss this channel.

function of relative asset supplies.[3] When the relative supply of a country's assets increases, we expect that the risk premium on those assets also increases. Either a widening interest-rate differential, or a widening spread between the expected future exchange rate and the current spot exchange rate, or both, can accommodate a rise in the risk premium, as equation (4) indicates.

The exact mix of interest-rate and exchange-rate adjustments associated with a change in the risk premium would seem important for evaluating sterilized intervention. That both interest rates and the expected exchange rate could change is entirely plausible (Obstfeld [1988]). Many studies, however, assume that because sterilized intervention leaves the monetary base unchanged, it also does not affect interest rates (Edison [1990]). Still others assume that the market determines the expected future exchange rate exogenously, so that sterilized intervention affects only the spot exchange rate. Although these are testable assumptions, no studies explicitly address them. A policy to depreciate the dollar could conceivably put upward pressure on domestic interest rates.[4]

Economists have not investigated the influence of intervention on the underlying components of the risk premium, because generally they have found little evidence that intervention operates through this channel. Researchers typically conclude that risk premiums exist and that they vary through time, but they have not succeeded in relating these changes to relative asset supplies.[5] With near unanimity, researchers have found the relationship to be either statistically insignificant or quantitatively unimportant. Three notable exceptions are Kearney and MacDonald (1986), who study intervention in Great Britain and attribute their findings in part to capital controls during the estimation period, Dominguez and Frankel (1989), and Dominguez (1990a). The last two studies, which look at the heavy intervention by West Germany, Japan, and the United States during the 1980s, are particularly interesting. Using a two-equation, simultaneous system (discussed later), Dominguez and Frankel find statistical evidence of portfolio effects, which could have practical relevance under some conditions. Studying a similar period, however, Humpage and Osterberg (1990) find mixed evidence of portfolio effects, but none of the coefficients seem large (see appendix).

In attempting to explain the empirical evidence, many economists observe that intervention volumes are too small relative to the outstanding stock of publicly held assets to have a perceptible impact on portfolio decisions and exchange rates. The total stock of publicly held U.S. government securities, for example, was nearly $2.3 trillion at the end of 1989. U.S. intervention amounted to $22 billion that year, a record volume, but it was less than 1 percent of the total stock of publicly held U.S. securities. Even if dollar interventions of the other 10 major industrial countries are included, the total amount represents only about 3 percent of the total stock of publicly held debt.[6]

Empirical research on risk premiums is subject to another qualification that is important for understanding intervention. Studies of risk premiums assume that exchange markets are rational in the sense of using all available information and of not making systematic forecast errors. Under this assumption, the market's failure to exploit all profitable interest-arbitrage opportunities must reflect a risk premium, not market inefficiencies. Recent work on expectations, discussed below, casts doubt on the validity of this assumption. If exchange markets are not perfectly efficient, what empirical studies interpret as a time-varying risk premium could instead reflect market inefficiencies. This would open another door through which intervention might affect exchange rates.

Signaling

Without a portfolio-adjustment effect, sterilized intervention will not affect exchange rates permanently. Nevertheless, central banks might maintain some temporary leverage in the market if they could improve the flow of information to the market and influence market expectations. Some economists have suggested that sterilized intervention functions as such.

When making exchange-rate quotations, perfectly efficient traders incorporate all available information, including their best guess about future policy developments. Reflecting this process, economists typically specify the exchange rate as a function both of contemporaneous fundamentals and of the expected future change in the exchange rate:

■ 3 See Hodrick (1987) for a comprehensive survey of the literature and Osterberg (1989) for a theoretical model that explicitly includes intervention.

■ 4 The results of Dominguez (1990b) raise interesting questions with respect to this issue (see appendix).

■ 5 Edison (1990) presents an excellent annotated bibliography that covers portfolio-adjustment models.

■ 6 See Ghosh (1989), Hutchison (1984), and Loopesko (1984).

$$(5) \quad s_t = z_t + \beta\,[E(s_{t+1} - s_t|\Omega_t)]\,,$$

where s_t is the current spot exchange rate; z_t represents a linear combination of fundamentals; $[E(s_{t+1} - s_t|\Omega_t)]$ is the expected change in the exchange rate conditional on all information currently available, Ω_t; and β is the elasticity of the current exchange rate with respect to expectations. Solving equation (5) by successively substituting in future values of the spot exchange rate, one obtains

$$(6) \quad s_t = (1+\beta)^{-1} \sum_{i=1}^{\infty} (\beta/1+\beta)^i E(z_{t+i}|\Omega_t),$$

which shows the spot exchange rate as the discounted sum of expected future values of the fundamentals.

Defining the relevant set of fundamentals is not an issue here. In general, economists employ factors that influence the supply and demand of domestic and foreign money.[7] For the purposes of this paper, equation (6) is important because it highlights the role of new information and expectations in determining exchange rates, and illustrates that intervention can affect current spot exchange rates if it provides information about fundamentals. Two such scenarios seem plausible: Through intervention, a central bank could reveal priority information about unanticipated changes in monetary policy to an otherwise perfectly efficient market.[8] Or, ignoring the possibility of priority information, a central bank might enhance the informational efficiency of the private sector through intervention, if it enjoyed unique economies in the acquisition and processing of publicly available information. I consider both of these cases below.

New Information

According to many economists, if sterilized intervention purchases (sales) of dollars create the expectation that the Federal Reserve System will tighten (ease) monetary policy, the dollar will appreciate (depreciate) as a result. Two recent studies focus directly on this mechanism and cast doubt on its universal applicability. Dominguez (1988), for example, reports evidence that following the October 1979 change in Federal Reserve operating procedures, the System signaled its intention to offset unanticipated money changes through intervention and that this intervention subsequently influenced exchange rates. Over two adjacent time periods, she found no evidence for signaling. Studying a more recent period, Klein and Rosengren (1991) conclude that neither the Federal Reserve nor the Bundesbank used intervention as a signal of policy changes. They did find, however, that coordinated intervention significantly affected daily exchange rates between the Group of Five Countries' (G5) Plaza meeting in September 1985 and the Group of Seven Countries' (G7) Tokyo meeting in May 1986, but at no later period.[9] Unilateral U.S. intervention also affected the exchange rate between the Tokyo meeting and the Louvre meeting in February 1987. The authors conclude that markets initially read intervention as a signal, but eventually learned that it was not intended as such.

If intervention is to affect exchange rates in a signaling context, it must provide new information about credible changes in future monetary policies. These studies suggest that intervention, at best, has fulfilled this task only once since the late 1970s. Perhaps we should expect this. Policy changes are not exogenous. Officials react to the state of the economy and to exchange markets in broadly discernible fashions, and private markets offer rewards to those who learn to predict those reactions accurately. When the market learns how central banks react, the scope for signaling diminishes. This limits the extent to which central banks can signal with intervention.

Why Signal with Intervention?

The signaling aspect of intervention is provocative not only for the possible channel of influence it portends, but also because of a question it raises: What possible signaling advantage does intervention have over a simple announcement of future policy intentions? Often, as already indicated, studies of intervention find a significant relationship after the Plaza meeting of the G5.[10]

■ **7** For a recent discussion, see Meese (1990).

■ **8** In most countries, the Treasury or the Ministry of Finance ultimately controls exchange-market intervention. Conceivably, intervention could then signal changes in fiscal policies. Given both the relative inflexibility of fiscal policy and the uncertainty about the effects of fiscal policy on exchange rates, I discount this possibility and discuss only monetary policy signals.

■ **9** The Group of Five Countries (G5) are France, West Germany, Japan, the United Kingdom, and the United States. The Group of Seven Countries (G7) are the G5 plus Canada and Italy.

■ **10** See also Marston (1988) for a discussion of signaling and a comparison of intervention after the Plaza period with intervention during the 1978 Carter dollar-defense period.

The dollar, however, began to fall against the mark and yen prior to the meeting, in anticipation of possible policy changes. Immediately after the meeting, the dollar fell precipitously, even before the major central banks began intervening. Through the subsequent days and weeks, as I indicate in a previous paper (Humpage [1988]), the dollar's day-to-day movements were not correlated with day-to-day intervention. Instead, the dollar responded to expectations generated by policy announcements and not to official currency transactions. When policymakers no longer reinforced or validated expectations of policy changes to promote a dollar depreciation, the dollar's decline slowed.

In attempting to explain the signaling mechanism, many economists have argued that the importance of intervention centers not on its ability to herald policy changes, but on its ability to cement governments' commitment to those policy changes.[11] Even when governments announce an optimal policy today, they can face incentives to renege on that policy tomorrow. Markets, of course, realize this and factor into their expectations the likelihood that policymakers will not follow through on their pronouncements. Policies allowing no opportunity for backing down, consequently, can have very different effects than similar policies that permit reneging.

To understand the role that intervention might play in cementing credibility, consider an example in which the Federal Reserve System tightens monetary policy to eliminate inflation and to prevent a continuing dollar depreciation. Markets recognize that political pressure will weigh on the System if, even temporarily, real interest rates rise and unemployment results. This possibility will temper market expectations. Intervention, however, increases the costs of reneging on an announced monetary policy change. Through intervention, the System acquires a short position in foreign currencies and a long position in dollars. Should it not subsequently tighten monetary policy sufficiently to appreciate the dollar, the dollar value of its foreign-currency debts will rise relative to its dollar assets. The United States will experience losses on its foreign-currency portfolio, which could have budgetary implications and could prove politically embarrassing.[12]

The importance of intervention profits in influencing central-bank monetary policy seems related to their size. Table 1 lists the reported Federal Reserve System profits from its foreign-exchange operations since 1975.[13] This table includes both realized profits, which reflect actual currency transactions, and unrealized profits, which result from currency swings that alter the value of foreign-exchange inventories.

Judging from the pattern and size of past profits, intervention probably has not significantly influenced the costs of reneging on Federal Reserve policy. Although on balance the System has shown a profit, it reported losses for 10 of the 15 years listed in the table without obvious political fallout. The reason is that balances associated with intervention have typically been small relative to profits remitted to the Treasury (usually less than 10 percent) and are only a trivial component of overall federal budget receipts (typically less than 2.5 percent).

In recent years, however, the System's portfolio of foreign currencies has increased sharply. To accommodate the rise, the Federal Open Market Committee increased the System's authorization for holding a net open position in foreign exchange to $25 billion in early 1990 from $12 billion in early 1989. This steep rise in holdings of foreign currency has greatly increased the chances of substantial unrealized losses should the dollar appreciate sharply.[14] The swings in profits could reach levels at which their practical significance might become important. As Obstfeld (1988, p. 43) notes, when the federal budget deficit is large, even marginal contributions become significant. The extent to which such considerations might influence monetary policy in the United States is unclear.

Signals and International Cooperation

Intervention might not provide a credible signal of future monetary policy in a particular country, but it could indicate to the market and to the participating governments the willingness of

■ **11** Dominguez distinguishes between signaling, as discussed above, and targeting, the sending of false signals. Because intervention leaves the monetary base unaffected, it allows central banks the opportunity to renege on policy. Central banks could not renege in this way very often without destroying their credibility, but in certain circumstances, sending false signals could prove effective. See Dominguez (1990b).

■ **12** As stated in Henderson (1984, p. 391), "... losses on foreign exchange positions can lead to significant political problems for the authorities. Thus, if the authorities undertake an intervention policy which would generate foreign exchange losses if their pronouncements about future monetary policy were not put into effect, there might be more reason for private agents to take these pronouncements seriously."

■ **13** Table 1 contains published data. Leahy (1989) attempts to capture the opportunity costs of intervention profits more closely.

■ **14** Leahy (1989) suggests how large portfolios make profits sensitive to exchange-rate changes.

TABLE 1

Federal Reserve Profits from Foreign Exchange Operations and Their Relationship to Treasury Receipts[a]

Year	Federal Reserve Profits[b]	Payments to Treasury	Ratio of Profits to Treasury Payments	Total Receipts[c]	Ratio of Payments to Total Receipts
1975	$-241.8	$ 5,382.1	-4.49 %	$280,642	1.92 %
1976	-25.1	5,870.5	-0.43	318,508	1.84
1977	-146.4	5,937.1	-2.47	365,199	1.63
1978	-505.7	7,005.8	-7.22	416,110	1.68
1979	-3.7	9,278.6	-0.04	480,526	1.93
1980	96.1	11,706.4	0.82	533,017	2.20
1981	-306.0	14,023.7	-2.18	622,485	2.25
1982	-149.6	15,204.6	-0.98	608,822	2.50
1983	-456.3	14,228.8	-3.21	612,915	2.32
1984	-454.8	16,054.1	-2.83	683,209	2.35
1985[d]	1,210.0	17,796.5	6.80	745,084	2.39
1986[d]	1,970.0	17,803.5	11.07	781,869	2.28
1987	1,804.3	17,738.9	10.17	868,996	2.04
1988	-510.9	17,364.3	-2.94	925,979	1.88
1989	1,204.2	21,646.4	5.56	979,923	2.21

a. Profits, payments, and receipts are expressed in millions of dollars.
b. Includes realized and unrealized profits.
c. Total of off-budget and on-budget items.
d. Unrealized profits; total profits not reported as a separate item.
SOURCES: "Income and Expenses of Federal Reserve Banks," Board of Governors of the Federal Reserve System, *Annual Report*, years 1975–1989; and "On-budget and Off-budget Receipts by Source," Table FFO-2, Department of the Treasury, *Treasury Bulletin*, years 1975–1989.

countries to coordinate their macroeconomic policy. Coordinated intervention could enhance the credibility of an announced coordinated monetary policy, because it might indicate that other countries found the proposed policy change appropriate and that they would not attempt to offset the exchange-rate implications. Indeed, some empirical results suggest that coordinated intervention is more effective than unilateral intervention. Dominguez (1988), for example, provides evidence in favor of this case. Moreover, Klein and Rosengren (1991) find a larger effect from coordinated intervention. Loopesko (1984), despite somewhat less conclusive results, finds that coordinated West German intervention had a significantly different effect than noncoordinated intervention. Humpage (1989) and Humpage and Osterberg (1990), on the other hand, could not attach special significance to coordination.

In a similar vein, intervention could provide a quick, simple, and relatively inexpensive way for countries to signal to one another their continuing willingness to coordinate macroeconomic policies. Game theoreticians recognize that players will often act in a cooperative manner, even without a formal enforcement mechanism, if each perceives cooperation to be to his advantage and if each believes that the others will not revert to a noncooperative behavior. Formal enforcement structures do not exist to ensure international macroeconomic policy coordination. One might then view intervention as a signal to other countries, not of a future policy change, but of an ongoing commitment to previously agreed-upon policy changes; that is, a signal that the intervening country will not revert to noncooperative behavior.

The G5 Plaza accord in September 1985, for example, focused on eliminating current account imbalances in West Germany, Japan, and the United States, with the implication that these countries would undertake appropriate macroeconomic policies. Given the lack of evidence in support of prolonged sterilized intervention, one might view the subsequent intervention, at least in part, as a signal to do just that. By late October of that year, however, the United States and

West Germany were not reinforcing the G5 agreement with additional policy changes, and by November, both countries expressed concern about the underlying implications of the G5 initiatives for their domestic monetary policies. Joint intervention ended in early November, and the United States refrained from intervening until early 1987. During 1986, despite some joint changes in discount rates, international policy was not undertaken cooperatively. As Frankel (1990, p. 24) notes, "... [James] Baker was repeatedly quoted in the press as 'talking the dollar down,' in large part as a weapon to induce the trading partners to cut interest rates."

Market Inefficiency

Economists characterize exchange markets as informationally efficient, because traders face strong incentives to consider all available information. Nevertheless, a sufficient amount of anecdotal and empirical evidence suggests that exchange markets are not perfectly efficient. If central banks enjoy an informational advantage, they may intervene and improve market efficiency.

Grossman and Stiglitz (1980) argue that if information is costly to discover and to transmit, exchange rates sometimes must reflect informational inefficiencies. These inefficiencies explain the sizable expenditures and frequent large profits of leading market participants. Hung (1991a) contends that many market participants do not base their trades on generally recognized economic determinants of exchange rates. Instead, so-called noise traders assess recent exchange-rate trends or "psychological factors," whose long-term economic significance is not always obvious. Hung states that because noise traders use broadly similar techniques and often respond to the same news, they can sometimes dominate exchange markets, creating bandwagon effects and moving the exchange rate away from levels consistent with economic fundamentals. Although such activities create profit opportunities for those who trade on fundamentals, Hung notes that, in the short term at least, the potential rewards might not be great enough to justify the costs and the risks.

A number of empirical studies also suggest that information inefficiencies do exist. Loopesko (1984), in an early study of daily intervention, finds that lagged independent and dependent variables help to explain day-to-day unexploited arbitrage profits. This suggests inefficiency in the processing of information. More recently, in an important study that questions the rationality of exchange-market expectations, Frankel and Froot (1987) find evidence that survey respondents exhibit biased expectations and that bandwagon effects exist, but are stabilizing. In an extension of this work that uses more-detailed survey data, Ito (1990) determines that individuals and industries hold dissimilar expectations about future exchange-rate movements, and that industrial groups exhibit "wishful thinking" with respect to forecasts. His results question the assumption that expectations are formed rationally and lend further support to the view that bandwagon effects occur in the short run. Also analogous in opening a role for intervention, but not strictly the same, other investigators note the possible existence of multiple exchange-rate equilibria, of exchange-rate overshooting, and of bubbles, even allowing for rational expectations.

The existence of temporary informational inefficiencies could create an occasion when central-bank intervention might improve the functioning of exchange markets, even without priority information about future monetary policies. Monetary authorities have long recognized this possibility. According to the Jurgensen Report (1983, p. 21), "The authorities in each of the Summit countries at times undertook large scale intervention when they judged that market participants had not taken full account of fundamental factors, [or] had only reacted slowly to changes in fundamentals...." Official exchange transactions following the G5 meeting at the Plaza in September 1985 adopted this view; delegates characterized exchange rates as inconsistent with underlying fundamentals.

For intervention to improve exchange markets by dampening or eliminating near-term exchange-rate deviations from their equilibrium paths, central banks must have timely and precise information about market fundamentals and their relationship to exchange rates. Otherwise, the central banks could not determine that exchange-rate movements represented a deviation from equilibrium rather than an adjustment to a new equilibrium. As already noted, attempts to relate market fundamentals to exchange rates have not been very successful.

Although inefficiencies may exist in the short run, persistent deviations from equilibrium eventually will create profit opportunities sufficient enough to offset the risks for those who trade on fundamentals. Little empirical evidence exists to suggest that short-term inefficiencies disrupt trade or investment flows. Many economists claim to have identified periods (such as 1984) when exchange rates departed from

fundamental levels and disrupted trade, but such cases are exceptional.

Hung (1991a, 1991b) also notes that to offset market inefficiencies, central banks must have timely information about the trading strategies of noise traders and should conduct their operations in secrecy. Humpage (1984) suggests that knowledge of official intervention can have destabilizing effects if the market interprets intervention purchases of dollars, for example, as evidence that the dollar is fundamentally weak. This seems possible in the case of noise trading. Hung theorizes that central banks undertake such intervention in secrecy, because if they convince the noise traders that private participants are affecting the market trend, then the noise traders might sustain the exchange-rate movement.

These comments imply that the occasions on which a central bank might successfully exploit market inefficiencies are probably rare. They do not belie the possibility that intervention could operate through such a channel. Indeed, some preliminary papers by Dominguez and Frankel (1989), Dominguez (1990a), and Hung (1991b) offer tentative support. All of these papers incorporate survey data, which have shown informational inefficiencies in exchange markets, and they all find some evidence that intervention can significantly affect exchange rates.

Dominguez and Frankel estimate a two-equation simultaneous system that includes a portfolio-adjustment equation. As noted previously, they also find a significant influence through the portfolio channel. In evaluating the quantitative significance of their results, they suggest that this channel alone might not be important, but when combined with an effect on expectations, the magnitude of the influence could become decisive.

Hung (1991b) regresses unexpected exchange-rate changes on numerous "news" variables and on U.S. intervention cumulated over the survey horizon. After deriving expected volatility from currency-option prices, she also regresses unexpected changes in exchange-rate volatility on the news variables and on intervention. Hung's results are mixed, but do show significant exchange-rate effects.

General Observations on the Empirical Evidence

An appendix to this paper briefly summarizes recent literature covering G3 intervention. These studies lend some support to signaling, in the sense that they all find periodic correlations among the relevant variables. What they do not find is a persistent relationship between intervention and exchange rates across time periods.

As Meese (1990) notes, economists have enjoyed little success in specifying a reliable model of exchange-rate determination. This limits our conclusions about the efficacy of intervention, especially sterilized intervention. In addition, virtually none of the work on intervention derives from solid structural models, incorporating theoretical interactions among intervention, investors' portfolios, central-bank monetary policies, or expectations.[15] The results are consistent with many stories about how intervention works and how failure to find an influence might reflect an inadequate specification. The task of evaluating intervention would be much easier if we had reliable guides to the equilibrium path of exchange rates and to the formulation of expectations.[16]

The lack of a strong model increases the danger that any observed relationship between intervention and exchange rates could depend on factors not directly measured in the experiment: statements by officials, the degree of market uncertainty, the state of the economy at home and abroad, other domestic policies, or international agreements on policy. This is particularly true with high-frequency data, since most economic variables are not measured more frequently than monthly. Often, these conditions and events in themselves enhance the credibility of policy announcements or convey information. If other factors are sometimes correlated with intervention, one might easily observe periodic, short-lived effects on exchange rates. Our ability to draw inferences about signaling from such correlations is limited.

Nonsterilized Intervention

Although sterilized intervention could temporarily affect exchange rates under some rather unusual circumstances, central banks must link their exchange-rate objectives with their monetary policies in order to influence rates regularly and permanently. Most central banks, including the Federal Reserve System, at times seem to operate in this fashion, either by not fully sterilizing their intervention or by occasionally adopting exchange-rate objectives for their monetary

■ **15** See Osterberg (1989) for a model of the risk premium that specifically introduces intervention.

■ **16** This paragraph reflects comments from Bonnie Loopesko.

policies. This section considers the possible conflicts that nonsterilized intervention can cause.[17]

Marston (1985) provides a comprehensive review of stabilization policy, indicating how different assumptions about the formulation of expectations, allowances for wage indexing, inclusions of wealth, and the extent of asset substitutability modify conclusions about exchange-rate policies drawn from small open-economy macroeconomic models. Although the qualifications and permutations are extensive, some general conclusions pertain to discussions of the appropriateness of nonsterilized intervention.

Most notably, Marston's survey shows that less exchange-rate flexibility promotes overall price stability only when temporary, domestic monetary (or financial) shocks predominate. In this case, using nonsterilized intervention to smooth exchange rates will not conflict with price stability, because monetary shocks raise or lower prices as they depreciate or appreciate a nation's currency.[18]

When real economic shocks predominate, however, greater exchange-rate flexibility promotes overall price stability, although the case seems weaker for supply shocks than for demand shocks.[19] Under such circumstances, attempting to smooth exchange rates might actually increase the price movements necessary to compensate for the shocks, because flexible rates aid price movements in eliminating excess supply or demand. Moreover, in responding to real shocks, intervention might reduce the credibility of a central bank's long-term commitment to price stability, by demonstrating that central banks would compromise that objective.

Marston's survey also weakens the argument that floating exchange rates insulate an economy from foreign shocks, by showing the large number of possible ways that exchange-rate changes might transmit these shocks. Nevertheless, his survey does not argue that fixed rates and intervention are superior to floating exchange rates on this score.

Given that no single exchange-rate regime promotes stability in all cases, a hybrid exchange-rate regime, with the degree of intervention contingent on the predominant nature of shocks, might seem optimal. Such would indeed be the case in a world where the central bank had perfect information about the nature of economic disturbances. Unfortunately, economists disagree on whether monetary or real shocks have been primarily responsible for the variation in real and nominal exchange rates since the early 1970s. Even in cases where monetary shocks predominate, the proper intervention response is not clear. Central banks should smooth exchange-rate movements in some cases and accentuate them in others.

The richness of Marston's survey suggests, whether intentionally or not, that economists do not agree on a specific variant of the open-economy macroeconomic model.[20] Consequently, one cannot reach an unequivocal conclusion about the benefits of targeting exchange rates with monetary policy. At best, the literature offers a qualified recommendation for nonsterilized intervention when a domestically produced disturbance is clearly monetary in nature. Such instances do occur and are sometimes readily discernible. In the 1977–79 period, for example, the dollar depreciated sharply as U.S. inflation accelerated relative to inflation abroad and as markets lost confidence in our willingness to eliminate it. A monetary contraction would have promoted a stronger dollar and stable prices.

III. The Implications for Policy

Economists have offered various theoretical arguments in support of sterilized intervention. Some researchers have found statistically significant and, at times, quantitatively important relationships between intervention and exchange rates. I have argued that this evidence does not endorse an active intervention policy, as the G3 countries have often conducted in recent years.

The empirical evidence generally does not find an economically significant relationship between the risk premium and intervention, as required by the portfolio-adjustment theory. This finding suggests that intervention, at least in volumes typically observed, cannot permanently alter exchange rates, independent of monetary policy. Central banks must weigh exchange-rate objectives in tandem with their inflation objectives.

Similarly, I question the idea that central-bank intervention provides a credible market signal of future policy intentions. Central banks do not generally seem to operate in this manner, and intervention does not have an obvious

■ **17** For an interesting discussion of nonsterilized intervention, expectations, and target zones, see Klein (1989) and Klein and Lewis (1991).

■ **18** Glick and Hutchison (1990) provide an easy-to-read exposition, which uses a simple model.

■ **19** See Glick and Hutchison (1990).

■ **20** See also Frankel and Rockett (1988)

comparative advantage over other methods of ensuring monetary policy credibility. Most important, such intervention cannot remain sterilized and effective; it does not constitute an independent policy instrument.

One might interpret the portfolio-adjustment and the monetary-signal arguments for intervention as requiring much larger magnitudes of intervention. The United States, for example, has built up its foreign-exchange reserves since the early 1980s to approximately $42 billion. While this might enhance our ability to intervene through these rather questionable channels, it also greatly increases our exposure to foreign-exchange losses.

Intervention, however, might play a role in international macroeconomic policy coordination, serving as a signal of continuing cooperation. Countries may not even intend such intervention primarily to influence exchange rates, although such an effect could be a desired side benefit. Although I know of no research specifically directed at this issue, the hypothesis is not inconsistent with recent patterns of intervention. It also may explain the interest in coordinated intervention, which other theories of intervention do not require, except to reduce the overall costs.

A recent body of literature suggests that foreign-exchange markets are at times informationally inefficient and that intervention, by improving market efficiency, could influence exchange rates. Indeed, some of the most interesting recent empirical support is consistent with this explanation. Nevertheless, how important are these inefficiencies? Do they obviously disrupt international commerce? Do central banks regularly meet the informational requirements to exploit this situation successfully? At best, this literature seems to support relatively small, secretive interventions under conditions of extreme market disorder.

Although the scope for affecting exchange rates through sterilized intervention seems narrow, nearly all economists recognize that countries can influence nominal exchange rates through their monetary policies. The literature indicates, however, that nonsterilized intervention can conflict with domestic price stability. Only when domestic monetary shocks create exchange-market disturbances will intervention remain consistent with price stability. Although this observation justifies targeting exchange rates with monetary policy under certain circumstances, it does not justify pursuing that policy through currency purchases in the exchange market, rather than through typical open-market operations. A small country lacking well-developed secondary markets in government bonds might find such intervention useful for conducting its monetary policy. The Swiss have traditionally conducted monetary policy through foreign-exchange purchases. Nevertheless, the benefits to larger countries, such as West Germany, Japan, and the United States, are not apparent.

Appendix: Studies of Recent G3 Intervention

This appendix summarizes recent empirical studies of U.S., West German, and Japanese intervention. One can interpret the results as broadly relating to a signaling approach, either because they incorporate high-frequency data or because their methodology suggests this approach. Edison (1990) presents a comprehensive survey of intervention literature, including earlier papers, research on the portfolio-adjustment mechanism, and research on intervention profits.

Humpage (1984) investigates dollar–mark interventions by the United States and other major developed countries for a one-year period following President Carter's November 1, 1978, intervention efforts. Using simultaneous Box–Jenkins techniques, he finds that both unanticipated U.S. intervention against marks and unanticipated foreign intervention against dollars were significantly correlated with the closing exchange rate. The results, however, suggest that official dollar purchases resulted in a dollar depreciation. The coefficients were economically insignificant. The reaction function suggests that central banks attempted to smooth exchange-rate movements, or leaned against the wind.

Loopesko (1984) finds that lagged, cumulative intervention was related to changes in ex-post arbitrage profits in 11 out of 24 cases. The strongest evidence is for Canadian dollars, West German marks, Japanese yen, and French francs in sample periods extending from late 1978 through 1981. This supports the portfolio-adjustment channel. Moreover, lagged exchange rates or profits were significant in about 21 of the cases, implying less-than-perfect market efficiency. In some cases for West Germany (when passive intervention was eliminated from the data), the effect of coordinated intervention was different from the effect of uncoordinated intervention.

In a unique and interesting paper, Dominguez (1988) studies the ability of intervention to signal monetary policy intentions between January 1977 and February 1981. She regresses

intervention on unanticipated money, which she calculates using survey data, and also regresses exchange-rate changes on intervention. Following the Volcker shift in operating procedures in October 1979, intervention signaled the Fed's intention to offset unanticipated fluctuations in money. This intervention bore a significant and correctly signed relationship to the exchange rate, suggesting that the market believed the signal. The results for the Carter–Miller anti-inflation period, beginning in November 1978, and for the Carter–Volcker credit control period, beginning in March 1980, do not support the signaling hypothesis.

Humpage (1989) looks at U.S. intervention, measured with dummy variables, from August 1984 through August 1987 and finds only three instances when intervention clearly affected exchange rates. In all cases, the association was with the first official transaction after a period of no intervention and followed an unusual event or announcement. This intervention also tended to lean *with* the wind. The impact seemed short-lived and not associated with subsequent official transactions following the initial intervention. Using actual intervention data instead of dummy variables over similar time periods, Humpage (1989) reexamines these findings. The only difference is that initial intervention sometimes appeared significant even if not associated with an unusual event or policy announcement. A distinction between coordinated and unilateral intervention was not important. These coefficient estimates could contain a simultaneity bias.

Dominguez and Frankel (1989) estimate a two-equation simultaneous system that considers both signaling and portfolio-adjustment channels over two subperiods: November 1982 to October 1984 and October 1984 to December 1987. The models use survey data for values of expected future exchange rates. The portfolio equation considers intervention both in absolute terms and relative to wealth. The researchers either cumulated intervention over the expectations horizon or from the start of the sample, or entered the individual intervention prior to the survey measure. The evidence offers support to the portfolio channel.

A second equation models expectations as extrapolations from past exchange-rate changes, but includes a dummy variable for reported "news" of any official actions to affect the exchange rate and a measure of reported intervention (the intervention series times the news dummy). Both of these intervention variables often prove significant, but the news dummy does so more often. The authors' quantitative analysis of the results suggests that intervention that has only a portfolio effect is quantitatively insignificant, but intervention that also alters expectations can be quantitatively significant.

Dominguez and Frankel focus on U.S. and West German intervention to affect dollar–mark exchange rates, because Japanese intervention data were not available. Dominguez (1990a) extends this work by including U.S. and Japanese intervention to affect the dollar–yen exchange rate from January 1985 to December 1988. The results were broadly similar.

Dominguez (1990b) investigates intervention and ex-post arbitrage profits from January 1985 to December 1987. Various subperiods show different results with respect to the significance and the sign of the coefficients for unilateral and coordinated intervention. Overall, however, coordinated intervention is more apt to show a significant and correctly signed coefficient than is unilateral intervention. Sometimes, notably in the G5 period (September through December 1985), the coefficient on coordinated intervention appears to exert an economically significant effect.

Although these conclusions hold for overnight transactions, they appear more often over one-month and three-month investment horizons. When the results hold only for the longer horizons, intervention dollar sales (purchases) must raise (lower) domestic interest rates, lower (raise) foreign interest rates, or appreciate (depreciate) the future exchange rate, but do not affect the spot exchange rate.

Humpage and Osterberg (1990), using a generalized autoregressive conditional heteroscedasticity (GARCH) model, examine the effects of daily U.S., West German, and Japanese intervention on ex-post arbitrage profits from January 3, 1983, to February 19, 1990. Following Loopesko (1984), they find cumulative intervention associated with a very small, significant increase in the mark–dollar risk premium, but find cumulative intervention in the yen–dollar market to be insignificant. The variance equation does not include cumulative intervention. Following Dominguez (1988), they differentiate between coordinated and unilateral intervention, and do not cumulate the data. Coordinated intervention was not significant in any mean or variance equations, nor was unilateral West German intervention. Unilateral Japanese intervention was significant in the mean with the wrong sign, and in the variance with a positive coefficient. Unilateral U.S. intervention was not significant in the mark–dollar equations, but was

significant in the yen–dollar, conditional-variance equation with a negative coefficient.

Building on theoretical arguments for intervention when noise trading persists, Hung (1991b) investigates the impact of U.S. intervention on both the level and volatility of exchange rates. She regresses unexpected exchange-rate changes on net intervention cumulative up to the realization of the expectation, and on four common news variables: unanticipated trade deficits, unemployment results, producer-price inflation, and changes in interest-rate differentials. Hung measures volatility by the standard deviation of exchange rates over two-week intervals and regresses unexpected exchange-rate volatility on the news variables and on cumulative gross intervention. (Hung estimates expected exchange-rate volatility from option prices.) The tests span two subperiods: December 1984 to December 1986, and January 1987 to December 1989. The results are mixed. U.S. intervention affects the yen exchange rate in both subperiods and influences the mark in the second period. U.S. intervention lowers exchange-rate volatility in the first period, but otherwise raises volatility. Hung interprets the disparate results as indicating that the effectiveness of intervention depends on market conditions and on the skill of those intervening.

Klein and Rosengren (1991) consider intervention from the September 1985 Plaza agreement to the October 1979 stock-market crash, proxying official transactions with dummies based on newspaper accounts. Interventions did *not* precede monetary policy changes with sufficient frequency to suggest that the United States or West Germany intended them as a signal of future monetary policy changes. Nevertheless, coordinated intervention did have a statistically significant and correctly signed impact on daily exchange-rate changes between the Plaza and Tokyo (May 1986) summits. Unilateral U.S. intervention influenced the exchange rate between the Tokyo and Louvre summits. Klein and Rosengren conclude that the market initially thought of intervention as a policy signal, but soon learned that central banks were not using it as such.

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