III. Sterilized Intervention in Emerging Asia: Is It Effective?

Has sterilized intervention in emerging Asia been effective in influencing the level, change, or volatility of exchange rates? The question arises because it is hard to rationalize the rapid buildup of foreign exchange reserves in the region as solely aimed at ensuring sufficient reserves (Tables 3.1 and 3.2). Certainly, some of the reserve accumulation has been precautionary in nature, and in some countries intervention reflects the operation of a fixed exchange-rate regime. But for countries that operate flexible regimes, reserve accumulation may reflect a desire to influence the level, change in, or volatility of the exchange rate. Indeed, since mid-2005 intervention has occurred in the context of upward pressure on currencies,

Table 3.1. Cumulative Foreign Exchange Flows and Reserve Accumulation[1]
(In millions of U.S. dollars)

	2000–07	2000–02	2003–04	2005–07
Indonesia				
Current account and FDI	40,962	15,332	7,559	18,071
Net capital inflows	-17,275	-9,233	-1,209	-6,834
Reserve accumulation	20,171	4,521	4,749	10,901
India				
Current account and FDI	30,903	14,969	16,622	-687
Net capital inflows	112,729	17,661	32,538	62,530
Reserve accumulation	163,622	35,553	60,068	68,001
Korea				
Current account and FDI	93,283	30,845	44,819	17,619
Net capital inflows	71,710	17,860	20,202	33,648
Reserve accumulation	164,902	47,358	77,654	39,890
Philippines				
Current account and FDI	14,230	-321	2,213	12,338
Net capital inflows	-6,452	60	-1,396	-5,116
Reserve accumulation	17,103	464	1,254	15,384
Thailand				
Current account and FDI	44,643	26,912	10,620	7,111
Net capital inflows	-32,585	-24,764	-10,939	3,119
Reserve accumulation	41,889	6,402	15,993	19,494

Source: IMF staff estimates.
[1] The reserve accumulation is from the central bank balance sheet (it is not derived from the BOP data). The data exclude net errors and omissions and current transfers. Net capital inflows exclude FDI.

Table 3.2. Reserve Adequacy Ratios
(As of end-2006)

	India	Indonesia	Korea	Philippines	Thailand
Gross reserves					
In months of imports of goods and services	8.2	4.8	7.7	4.4	6.0
As ratio of short-term external debt[1]	9.4	1.5	2.1	1.6	2.0

Source: IMF staff estimates.
[1] Residual maturity.

suggestive of a "leaning against the wind" approach. This chapter concentrates on five managed-floating countries that have conducted intervention—India, Indonesia, Korea, the Philippines, and Thailand—over the period 2000–07.

An important goal of this chapter is to ascertain the impact of intervention on exchange rates. While the theoretical literature on its effects has advanced, and central bankers indicate that they view intervention as an effective policy tool (Neely, 2007), inferring its effects remains complicated. This study, like many in the literature, faces data limitations and methodological challenges. In particular, it is hampered by the use of monthly reserves data as a proxy for intervention and standard problems such as the simultaneity of exchange rates and intervention. Furthermore, the lack of a counterfactual also makes assessing the effectiveness of intervention difficult.

Recognizing such difficulties, this chapter finds limited evidence of systematic links between exchange rates and intervention. The data show that the authorities have intervened on both sides of the market. Early in the sample period, some authorities were "leaning against the wind" by selling foreign

Note: The main authors of this chapter are Hali Edison, Roberto Guimarães-Filho, Charles Kramer, and Jacques Miniane.

exchange, while later in the sample they bought foreign exchange during periods of protracted appreciation pressures on their currencies. Overall, the empirical results speak loudest on volatility, suggesting that intervention may be associated with lower exchange rate volatility.

What Is Sterilized Intervention?

Foreign exchange intervention is the purchase or sale of foreign exchange by a monetary authority, either sterilized or unsterilized. *Unsterilized intervention* involves the purchase of foreign currency with domestic currency, which changes the monetary liabilities of the monetary authorities, and thus the monetary stance. *Sterilized intervention* includes both this exchange of currencies and monetary operations (such as open-market sales or purchases of securities) to undo the effects of that exchange on monetary liabilities. Sterilized intervention is thus equivalent to a swap of securities denominated in home currency for those denominated in foreign currency, with a corresponding change in the currency composition of the private sector's securities holdings. The distinction between unsterilized and sterilized intervention is important: changes in the monetary stance would naturally affect the exchange rate, so it would not be surprising to find that unsterilized intervention is effective. By contrast, sterilized intervention acts through subtler channels (as discussed later), which may not always work.

The distinction between sterilized and unsterilized intervention is also important in relation to the monetary framework. For example, four of the five countries studied here—Indonesia, Korea, the Philippines, and Thailand—have adopted inflation-targeting frameworks, which may constrain intervention. For instance, if an inflation-targeting country wished to resist exchange rate pressures, it could adjust its monetary policy stance through intervention. But protracted one-sided intervention could, in principle, raise inconsistencies with inflation targeting. For example, unsterilized intervention could create a surge of domestic liquidity that led to an undue loosening in the domestic monetary stance, or could keep the exchange rate from adjusting to a level consistent with achieving the inflation target. It is thus not surprising that the countries in the sample generally sterilize (as discussed below).

Motives for Intervention, Channels for Effectiveness, and Evidence from the Literature

Typically, intervention aims at the following:

- *Influencing the level of the exchange rate.* The authorities may be concerned that the exchange rate has moved away from its equilibrium level, unduly affecting competitiveness (note that none of the five countries examined targets a specific exchange rate level).
- *Dampening exchange rate changes.* The authorities may also intervene to slow the speed of exchange rate changes. For example, this "leaning against the wind" may buy the export sector time to adjust to an appreciating exchange rate trend.
- *Smoothing exchange rate volatility.* The authorities may intervene to prevent exchange markets from becoming disorderly. In particular, excessive volatility may impede the orderly functioning of the market, leading to a widening of bid-ask spreads and loss of liquidity.
- *Accumulating reserves.* The authorities may intervene to build an inventory of foreign currency assets. Following the financial crises of the 1990s, many countries, including those in this study, embarked on intervention partly as a self-insurance policy aimed at reducing external vulnerabilities and sovereign risk.

Sterilized intervention can work through two main channels:[16]

[16] Edison (1993) is an early survey of the intervention literature; Sarno and Taylor (2001) provide a more recent survey

- *Portfolio balance channel*. Sterilized intervention may affect the exchange rate if it changes the risk premium, which arises when home and foreign bonds are imperfect substitutes.[17] That is, the risk premium may change to induce the private sector to adjust its holdings of foreign and domestic bonds. If so, the exchange rate would move to equalize risk-adjusted returns on domestic and foreign currency assets.[18]

- *Signaling channel*. Sterilized intervention may have effects through the signaling channel if it changes expected future values of the exchange rate or its fundamentals. In particular, this channel would imply a systematic relationship between intervention and future policies.

Prior research on the effectiveness of these channels focuses mainly on advanced countries, and finds weak evidence that sterilized intervention affects exchange rates.[19] The empirical literature uncovers effects that are statistically significant but economically small.[20] Some research finds effectiveness when the exchange rate is away from fundamentals, but such effects are very short lived and at times tend to increase volatility. In addition, for the major currencies, evidence that sterilized intervention *dampens* volatility is weak.[21]

The literature on the effectiveness of intervention in emerging markets is still in its infancy, owing in part to limited availability of data. Existing studies generally find weak evidence of effectiveness.[22] In contrast, a study on India finds that intervention dampens volatility (but does not affect the level of the rupee). A recent cross-country study, using a sample of emerging markets and small advanced countries, finds that resisting nominal exchange rate appreciation through sterilized intervention is likely to be ineffective when capital flows are persistent (IMF, 2007b).

In principle, intervention could be more effective in emerging market countries than in advanced countries:

- *Emerging markets assets may be less perfect substitutes internationally than advanced country assets*. Indeed, Chinn and Ito (2007) show that countries in our sample are less financially open to international transactions than advanced economies. In addition, emerging market currencies may be riskier than major currencies, especially during periods of financial market volatility, and investors typically demand a risk premium for holding emerging market bonds.

- *In emerging markets, intervention is larger relative to foreign exchange turnover*.[23] Despite its rapid growth in recent years, foreign exchange turnover is still relatively small compared with advanced economies. For example, average *daily* turnover

of theory and empirical evidence. Truman (2004) concludes "Intervention has definite limits as a policy instrument. Its effectiveness is uncertain and imprecise, and therefore it is at best blunt or a blunted instrument."

[17] The risk premium is the differential between home and foreign interest rates, adjusted for the expected depreciation of the foreign currency.

[18] The well-known empirical violations of uncovered interest parity, surveyed in Engel (1996) and, more recently, Chinn (2006), are consistent with the assumptions underpinning the portfolio balance channel.

[19] Typically, the literature focuses on the effects of intervention on the nominal bilateral exchange rate vis-à-vis the U.S. dollar, since most countries intervene against the dollar.

[20] Edison (1993) surveys the literature from the 1980s through early 1990s. Dominguez and Frankel (1993) found some evidence in favor of the portfolio and signaling channels while Obstfeld (1990) found that portfolio balance effects are statistically significant but small. For Japan, Ito (2002) found that large and infrequent intervention had quantitatively small but statistically significant effects on the dollar-yen nominal exchange rate.

[21] Dominguez (2006) and Edison, Cashin, and Liang (2006) have found that intervention increases exchange rate volatility, in contrast with claims by central banks that intervention does not increase (or is not associated with an increase in) volatility (Neely, 2007)

[22] Guimarães and Karacadag (2004), using daily data for Mexico and Turkey, find that intervention tends to increase exchange rate volatility. Disyatat and Galati (2005) find weak evidence that intervention is effective in the Czech Republic. On India, see Pattanaik and Sahoo (2003).

[23] See Neely (2007) and Fatum and Hutchinson (2006) for evidence supporting this view.

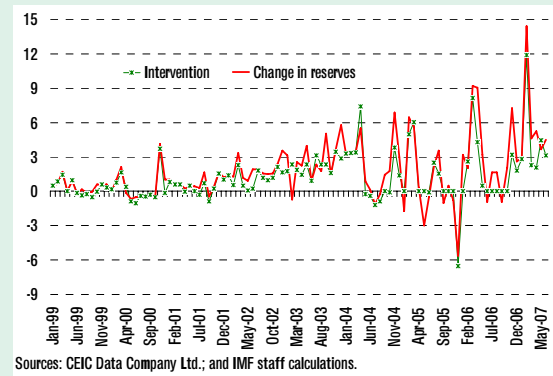
represented about 5¼ percent of GDP in Japan and the United States (taken together) in 2007, while it averaged only 2½ percent of GDP in the five countries examined here (Table 3.3).

Table 3.3. Foreign Exchange Turnover
(Daily average net of inter-dealer double-counting; in millions of U.S. dollars)

	India	Indonesia	Japan	Korea	Malaysia	Philippines	Thailand	United States
2001	3,416	3,857	146,780	9,597	1,248	1,061	1,896	253,654
2004	6,642	2,301	198,870	19,808	1,612	671	2,869	461,291
2007	34,085	2,809	238,425	33,396	3,417	2,320	6,171	663,611
				(In percent of reserves)				
2001	7.4	14.2	37.1	9.3	4.2	7.9	5.9	440.1
2004	5.2	6.6	23.8	10.0	2.4	5.1	5.9	607.8
2007	20.0	6.8	27.1	14.0	4.2	11.6	9.5	1,209.8
				(In percent of GDP)				
2001	0.7	2.4	3.6	2.0	1.4	1.5	1.6	2.5
2004	1.0	0.9	4.3	2.9	1.4	0.8	1.8	3.9
2007	3.5	0.7	5.5	3.5	2.1	1.7	2.8	4.8

Sources: Bank for International Settlements; and IMF staff estimates.

Figure 3.1. India: Intervention and Change in Reserves
(In billions of U.S. dollars)



Sources: CEIC Data Company Ltd.; and IMF staff calculations.

Has Intervention Been Effective in Emerging Asia?

Data Issues

Measuring intervention is a key hurdle for properly assessing its effectiveness. Our sample of countries lack high-frequency publicly available data on intervention, requiring the use of a proxy series. Given this constraint, this study proxies intervention with monthly changes in gross reserves. Actual intervention and the change in gross reserves differ owing to valuation changes and income flows from reserves, but for the countries studied here, the proxy tracks intervention reasonably well. (For the case of India, see Figure 3.1.) In particular, for countries in this study, the correlation between changes in gross reserves and actual intervention data generally ranges around 0.8–0.9 (for countries in the sample, intervention data are confidential, except for India, which publishes monthly data). The main drawback of the data is their monthly frequency, which makes it difficult to disentangle the simultaneity of the exchange rate and intervention, and impossible to detect short-lived effects.[24]

The proxy data show common patterns for intervention across countries, albeit with the magnitude varying substantially. Figure 3.2 shows that countries in the region have leaned more heavily toward purchases of foreign currency than sales, particularly India and Korea. Similarly, countries appear to have stepped up intervention recently, particularly India, Indonesia, Thailand, and the Philippines. However, the size of intervention relative to foreign exchange turnover has varied substantially across the sample countries. For instance, over the period 2005–07 absolute monthly intervention averaged 11 percent of *daily* foreign exchange market turnover in India, 50 percent in Indonesia, 5 percent in Korea, 38 percent in the Philippines, and 22 percent in Thailand.[25]

Intervention in the region has often followed a "leaning against the wind" pattern. As Figure 3.2 shows, countries have often stepped up foreign exchange purchases during periods of protracted

[24] Ideally, intervention should also be adjusted for passive intervention, for example, when the monetary authorities accumulate reserves for the purpose of treasury operations and not to affect the exchange rate. However, such adjustments are not possible in our sample given lack of data.

[25] Daily turnover data are for 2007, kindly provided by the BIS. Note that it is common in the literature to measure monthly intervention relative to *daily* turnover.

appreciation pressures on their currencies. For example, this occurred in India between June 2002 and April 2004 and between August 2006 and June 2007. It also took place in Korea between April 2002 and June 2007 and in the Philippines between September 2005 and June 2007.[26] Such "leaning against the wind" complicates inferences on the effectiveness of intervention since the simultaneous observation of foreign exchange purchases and domestic currency appreciation cannot be interpreted as evidence that intervention was ineffective. For instance, in the absence of intervention the exchange rate might have followed a more appreciated path.

Countries in the sample appear to have increasingly intervened through forwards and swaps (Box 3.1). India and Indonesia have reportedly intervened in spot markets only, but the Philippines and Thailand have increasingly used forwards and swaps for both outright intervention and sterilization (Figure 3.2).[27] Since there is no a priori reason to believe that forward or swap intervention would have a qualitatively different effect on the exchange rate than spot intervention, excluding such operations would underestimate actual intervention. Accordingly, an expanded measure of intervention was computed as the change in gross reserves plus the change in the net forward position (including the forward leg of swaps).

In our sample, intervention has been mainly sterilized. To assess the degree of sterilization, the contribution of net domestic assets to reserve money growth is regressed on the contribution of net foreign assets to reserve money growth.[28] Under full sterilization, the coefficient would be –1, indicating that when the monetary authority purchases foreign currency assets, it sells an equivalent amount of net domestic assets to neutralize the effect on reserve money.[29] This appears to be the case: the null hypothesis of full sterilization cannot be rejected in most cases, and even when it can, the coefficient is close to –1 (Table 3.4). This is unsurprising: with the exception of India, all countries in our sample follow inflation targeting, which implies—in the absence of changes in monetary policy stance—routine sterilization of the effects of intervention. In effect, then, the data for reserve changes can be treated as measuring sterilized intervention.

Table 3.4. Sterilization Coefficient[1,2]

	2000–07	2000–02	2003–04	2005–07
India	-0.79	-0.72 *	-1.00 *	-0.72
Indonesia	-0.82 *	-0.85 *	-0.79 *	-0.77 *
Korea	-1.00 *	-0.93 *	-1.02 *	-1.06 *
Philippines	-0.85 *	-0.72	-0.92 *	-1.15 *
Thailand	-0.87	-0.91 *	-0.69	-0.90 *

Source: IMF staff calculations.

[1] The sterilization coefficient is the coefficient from a regression on the contribution of net domestic assets to reserve money growth on the contribution of net foreign assets to reserve money growth. Net domestic assets in the regression are defined as reserve money minus net foreign assets.

[2] An asterisk denotes that the null hypothesis of full sterilization (a coefficient equal to or smaller than -1) cannot be rejected at the 95 percent confidence level.

Testing Effectiveness

As a first step to gauge the effectiveness of intervention, this chapter employs simple correlation analysis. Most of the results are based on contemporaneous correlations between intervention and the level, the change, and the volatility of the exchange rate. The exchange rate used is the bilateral rate against the U.S. dollar, as this is the key exchange rate that authorities focus on when

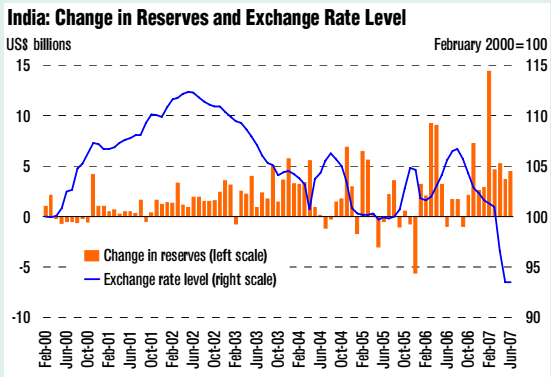
[26] Note that June 2007 marks the end of our sample period, not necessarily the end of these "leaning against the wind" episodes.

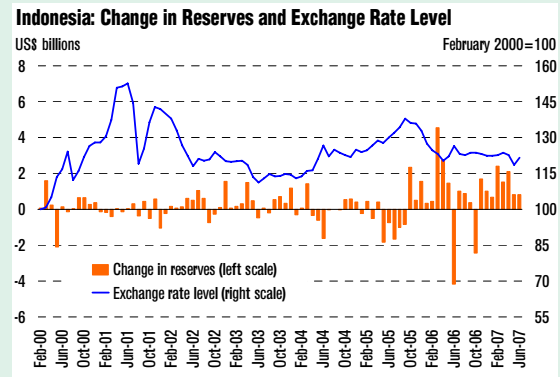
[27] Data for Korea start in January 2005; most of its activity in forwards and swaps since then has reflected a slow unwinding of a long forward position, which was mostly built over 2003 and 2004.

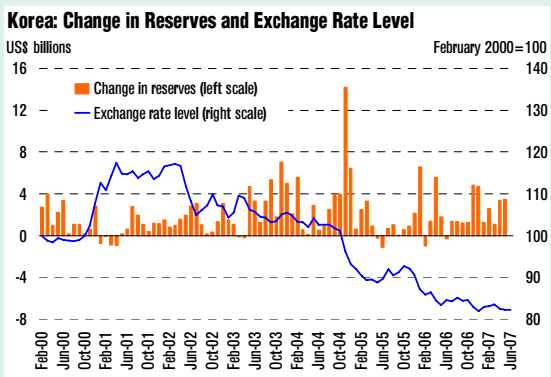
[28] This is an imperfect estimate of sterilization, since reserve money may be changing owing to (for example) shifts in money demand. Also, open market operations of domestic assets are not the only way to sterilize intervention; for example, swaps can be used as well. Further, note that net domestic assets are defined here as reserve money minus net foreign assets, which includes the central bank's net worth.

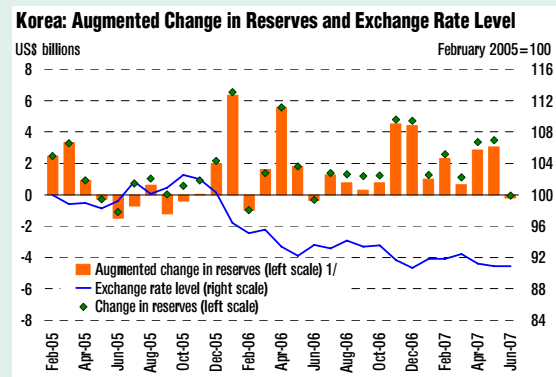
[29] If (narrow) money demand is constant or stable in the very short term, the regressions correctly test for sterilization even for countries that target a short-term interest rate.

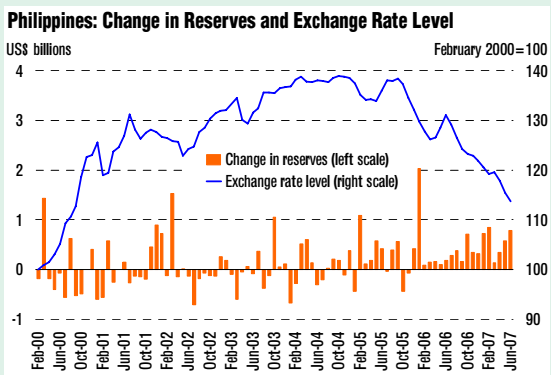
Figure 3.2. Selected Asia: Foreign Exchange Intervention

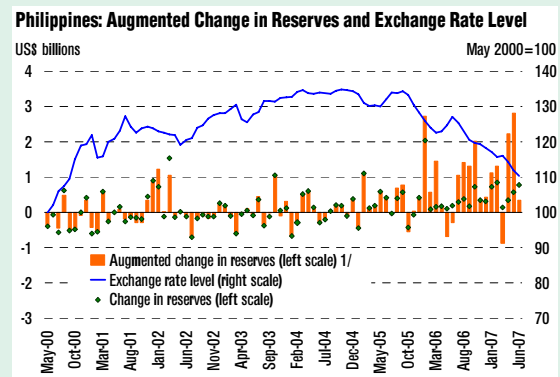


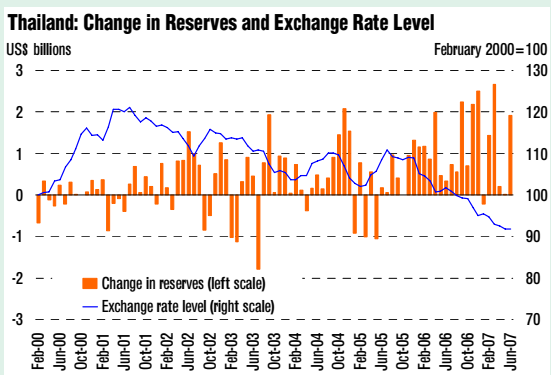


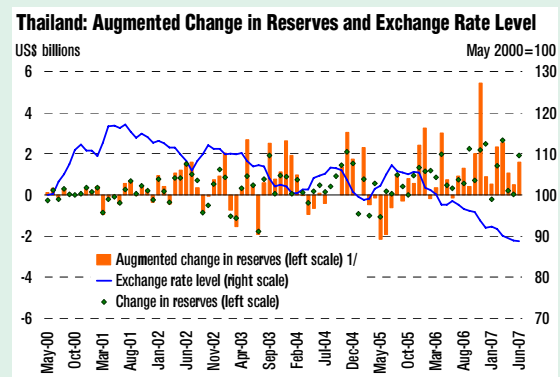












Sources: CEIC Data Company Ltd.; IMF, *International Financial Statistics*, and staff calculations; see also: http://www.imf.org/external/np/sta/ir/kor/eng/curkor.htm#cnotes, http://www.imf.org/external/np/sta/ir/phl/eng/curphl.htm, and http://www.imf.org/external/np/sta/ir/tha/eng/curtha.htm.

[1] Equal to changes in gross reserves plus changes in the net forward reserve position.

Box 3.1. The Mechanics of Intervention

The balance sheet of the monetary authority helps illustrate the important distinction between sterilized and unsterilized intervention. Like any other balance sheet, it is organized according to the principles of double-entry bookkeeping. The acquisition of an asset by the monetary authority appears on the asset side of the ledger. Similarly, any addition to the authorities' obligations appears on the liabilities side.

An *unsterilized intervention* consists of a purchase (or sale) of foreign exchange from the private sector (commercial banks), with a purchase increasing the monetary authority's net foreign assets holdings (upward-pointing arrow). At the same time, the monetary authority credits the reserve accounts of commercial banks, corresponding to an automatic increase in the monetary base. This action is consistent with a traditional open market operation, in which the monetary authority affects the money supply and interest rates through a change in its holdings of foreign assets (unsterilized intervention). If the monetary authority *sterilizes* this intervention, it would sell domestic bonds to commercial banks (downward-pointing red arrow), mopping up the liquidity associated with the initial operation. The result of these operations is that the monetary base remains constant while the composition of the monetary authority's assets changes (higher NFA, lower NDA). Similarly, the composition of private sector holdings of foreign and domestic assets also changes, which may affect the exchange rate through the portfolio balance channel.

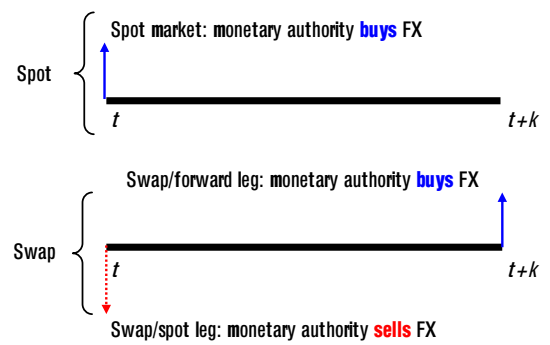
Central Bank Stylized Balance Sheet

Assets	Liabilities
Net foreign assets ↑	Monetary base ↑↓
Foreign currency	Currency in circulation
Foreign bonds	Reserve accounts of commercial banks
Gold	
Net domestic assets ↓	Net worth
Domestic bonds	Accumulated surpluses and net interest and capital gains
Loans to commercial banks	

Source: IMF staff.

Sterilized intervention may be conducted through *swap and forward* operations. For instance, in an outright forward intervention, the monetary authority purchases or sells foreign exchange in the forward market. Initially, this transaction is equivalent to sterilized intervention: it has no immediate impact on the monetary authority's monetary liabilities, as it is settled at a future date. However, when the transaction is settled, it affects the monetary authority's balance sheet (as in the case of unsterilized intervention), unless there is another offsetting transaction (e.g., if the forward contract is rolled over). Swaps can also be used to sterilize intervention. For example, if the monetary authority purchases foreign exchange in the spot market, it can immediately mop up the effects on liquidity by selling foreign exchange (first leg of the spot-forward swap) and simultaneously reverse the first leg of the swap with a forward purchase of foreign exchange (second leg of the swap). This swap intervention also gives rise to a net forward position, which if left unsterilized would have a delayed impact on reserves and the monetary base. However, as in the case of the outright forward, the monetary authority has the option of rolling over its swaps to leave the monetary base unchanged.

Spot-Swap Sterilized Intervention



Source: IMF staff.

intervening.[30] Because the exchange rate is expressed in units of domestic currency per U.S. dollar, a positive correlation between intervention and the level of the exchange rate would indicate that higher intervention is associated with a more depreciated domestic currency, providing evidence of effectiveness.[31] Similarly, a positive correlation between intervention and the change in the exchange rate would indicate that higher intervention is associated with a weaker appreciation (or stronger depreciation), which also provides evidence that intervention may slow the speed of appreciation. Finally, one would also expect to find a negative correlation between intervention and volatility if intervention dampens exchange rate volatility.

These simple correlations were buttressed with regression and vector auto-regression (VAR) analysis. Some of the regressions partially account for the simultaneity of intervention at the monthly frequency and are consistent with "leaning against the wind" and the protracted nature of intervention in our sample. In addition, the VAR analysis attempts to uncover lagged effects of intervention on the level or volatility of the exchange rate, as well as to differentiate between anticipated and unanticipated intervention. Because the regressions did not uncover significant information beyond what our correlation analysis shows, we concentrate here on the correlations (see Box 3.2 for more details on the regression and VAR analysis).

Results

Level of the exchange rate. The correlation between intervention (measured by the change in gross reserves) and the level of the exchange rate is weak (Table 3.5). For most countries and subperiods, the sign of the correlation indicates that foreign currency purchases are associated with an *appreciation* of the domestic currency, the opposite of what one would expect, although the correlation coefficients are generally insignificant. Such correlations could simply indicate that the authorities "lean against the wind," purchasing foreign exchange when the domestic currency appreciates. However, computing correlations between intervention today and the level of the exchange rate with a lag, or attempting to control for the endogeneity of intervention in regressions, yields no further evidence of effectiveness (Box 3.2).[32]

Table 3.5. Change in Reserves and Level of the Exchange Rate[1,2]

Contemporaneous	2000–07	2000–02	2003–04	2005–07
India	-0.21 *	0.46 *	-0.35	-0.22
Indonesia	-0.15	-0.21	-0.24	-0.30
Korea	-0.15	-0.33	-0.59 *	-0.36
Philippines	-0.03	0.00	0.06	-0.27
Thailand	-0.33 *	0.06	-0.29	-0.34

Source: IMF staff calculations.

[1] The table displays the contemporaneous correlation between changes in gross reserves and the level of the exchange rate against the U.S. dollar.

[2] A negative correlation indicates that foreign reserve acquisitions are associated with an appreciation of the domestic currency, and an asterisk denotes that the correlation is significantly different from zero at the 95 percent confidence level.

Changes in the exchange rate. The correlations between changes in gross reserves and the change in the exchange rate are also negative (Table 3.6), and

Table 3.6. Change in Reserves and Change in the Exchange Rate[1,2]

Contemporaneous	2000–07	2000–02	2003–04	2005–07
India	-0.31 *	-0.48 *	-0.45 *	-0.17
Indonesia	-0.19	-0.09	-0.35	-0.48 *
Korea	-0.47 *	-0.34 *	-0.51 *	-0.64 *
Philippines	-0.31 *	-0.19	-0.25	-0.28
Thailand	-0.49 *	-0.49 *	-0.47 *	0.50 *

Source: IMF staff calculations.

[1] The table displays the contemporaneous correlation between changes in gross reserves and changes in the exchange rate against the U.S. dollar.

[2] An asterisk denotes that the correlation is significantly different from zero at the 95 percent confidence level.

[30] For Korea, calculations were recomputed using the bilateral rate against the yen, but the results were very similar to those using the U.S. dollar. Further work could investigate whether intervention in the region has affected the level or volatility of the real exchange rate.

[31] Note that "leaning against the wind" policies may generate negative correlations.

[32] Using the expanded measure of intervention (including the change in the net forward position) for Korea and the Philippines does not qualitatively affect the results.

Box 3.2. The Effectiveness of Intervention: Additional Tests

In addition to estimating contemporaneous and lagged correlations between intervention and the level, change, and volatility of the exchange rate, simple regressions were also estimated. These regressions should not be seen as structural models of the exchange rate. Two issues need to be kept in mind when interpreting the results: (1) there is substantial academic evidence that floating exchange rates (admittedly not a perfect description of the currencies examined here) cannot be distinguished from a random walk at horizons of two years or less (Engel, Mark, and West, 2007); and (2) given the monthly frequency of the data, there is substantial simultaneity between the exchange rate and intervention.

Two-stage least-squares were applied to adjust for simultaneity. In the first stage, intervention was regressed on the lagged change in the exchange rate and lagged intervention. In the second stage, the exchange rate change is regressed on the predicted value of the intervention from the first-stage regression. The first-stage regression specification is consistent with the leaning against the wind and the protracted nature of intervention in our sample. Specifically,

$$\text{First stage: } I_t = a + b * I_{t-1} + c * \Delta S_{t-1} + u_t$$

$$\text{Second stage: } \Delta S_t = d + e * I_t^{\,p} + v_t,$$

where I denotes intervention, ΔS denotes the change in the exchange rate (expressed in log differences, with a negative change signifying appreciation), a, b, c, d, and e denote parameters to be estimated, and u and v denote regression errors. The second-stage regression was also estimated with the volatility of the exchange rate on the left-hand side.

In most of the first-stage regressions, the instruments worked well in explaining intervention. However, in most cases the coefficient of interest (e) was statistically insignificant at 95 percent confidence, and/or of the wrong sign (negative in the case of the exchange rate change regressions; positive in the case of the volatility regressions), whether using the change in the exchange rate or the volatility of the exchange rate in the second-stage regression. Only in a handful of cases (such as the volatility regression for the Philippines) was the coefficient significant and of the expected sign.

In an additional exercise, vector auto-regressions (VAR) were applied for each country. The specification of the VAR included the exchange rate (in either level terms or first differences), intervention, and interest rate differentials (measured as the difference between the domestic 3-month money market or treasury bill rate and the 3-month U.S. treasury rate). The results indicate that the exchange rate does not respond to intervention shocks. The impulse response functions show that the effect of intervention on the exchange rate is generally statistically insignificant and of the wrong sign. This result is robust to the ordering used to identify the shocks and to the VAR specification. In one case, India, some of the responses of the exchange rate to intervention were of the correct sign (higher intervention leads to a more depreciated exchange rate) but statistically insignificant.

hence provide no evidence that intervention has slowed the speed of appreciation.

Volatility of the exchange rate. There is some modest evidence that intervention affects the volatility of the exchange rate.[33] While the correlations are generally small and statistically insignificant, their sign is mainly negative, suggesting that intervention has been associated with lower volatility (Table 3.7). This result is robust to adjustments for delayed effects of intervention, the endogeneity of intervention, and the measure of volatility.[34]

Table 3.7. Change in Reserves and Volatility of the Exchange Rate[1,2]

Contemporaneous	2000–07	2000–02	2003–04	2005–07
India	0.05	-0.39 *	-0.11	-0.09
Indonesia	-0.18	-0.15	-0.34	-0.20
Korea	-0.09	-0.19	-0.04	-0.01
Philippines	-0.22 *	-0.30	-0.12	0.16
Thailand	-0.07	-0.13	0.05	0.02

Source: IMF staff calculations.

[1] The table displays the contemporaneous correlation between changes in gross reserves and the realized volatility of the exchange rate against the U.S. dollar.

[2] An asterisk denotes that the correlation is significantly different from zero at the 95 percent confidence level.

Conclusions

This chapter finds limited evidence of systematic links between sterilized intervention and exchange rates. The limited evidence for effectiveness may be surprising to some. The low degree of substitutability of emerging market assets and the large size of interventions relative to currency market turnover in emerging markets would suggest that intervention could have a sizable effect on exchange rates. However, there is some modest evidence that intervention dampens volatility, which is consistent with the stated objectives of some monetary authorities.

There are several factors that could weaken the effectiveness of intervention in emerging Asia. First, persistent structural factors may be driving the appreciation of the currency, obscuring any effect of intervention beyond a short period. Second, to the extent that sterilized intervention prevents the domestic interest rate from adjusting (especially downward), it would have limited effects on capital flows driven by interest differentials, thereby failing to alleviate upward pressure on the currency. In addition, intervention aimed at building reserves would not necessarily signal future policy changes and hence might not be expected to exert any effect on the exchange rate.

Finally, the results need to be interpreted with a grain of salt. Data limitations and methodological challenges hamper the assessment of the effectiveness of intervention. While the results in this chapter suggest that there is limited evidence of effectiveness, the fact that the monetary authorities have actively intervened suggests that they believe the intervention has been effective. This is also consistent with the views of central banks in emerging markets (Neely, 2007) and with the findings that intervention may work over a very short time horizon in advanced economies. Better data availability and continued research into the channels and motives for intervention in emerging markets countries could lead to a fuller understanding of the effectiveness of intervention in the region.

[33] Volatility was estimated with daily exchange rate data and then aggregated at the monthly frequency, based on two measures: a fitted GARCH (1,1) process on the daily log difference of the exchange rate, and realized volatility based on the rolling 20-day moving average of the square of the log difference of the exchange rate.

[34] When controlling for the endogeneity of intervention using two-stage least squares, only in the Philippines was intervention associated with lower volatility in a statistically significant way.