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Is There Room for Foreign Exchange Interventions under an Inflation Targeting Framework?

Evidence from Mexico and Turkey

by

Ilker Domaç[†] and Alfonso Mendoza[‡]

Abstract

The salient characteristics of emerging market economies coupled with the increasing adoption of inflation targeting in these countries has stimulated much debate about the role of the exchange rate in inflation targeting regimes. The paper aims at shedding more light on this issue by investigating whether central bank foreign exchange interventions have had any impact on the volatility of the exchange rate in Mexico and Turkey since the adoption of the floating regime. To this end, the study, using daily data on foreign exchange intervention, employs an Exponential GARCH framework. Empirical results suggest that both the amount and frequency of foreign exchange interventions have decreased the volatility of the exchange rates in these countries. The findings corroborate the notion that if foreign exchange interventions are carried out with finesse and sensibly—i.e., not to defend a particular exchange rate—they could play a useful role under an inflation targeting framework in containing the adverse effects of temporary exchange rate shocks on inflation and financial stability.

***Keywords*:** Inflation targeting; exchange rate volatility; central bank intervention; E-GARCH.

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† Corresponding author. The World Bank. Email: idomac@worldbank.org.
‡ University of York**.** Email: amv101@york.ac.uk.

1. Introduction

The successful performance of a number of industrial countries that adopted *inflation targeting* (IT) has rendered this monetary policy framework an attractive alternative for emerging market economies (EMs). Indeed, a number of EMs have already instituted IT or some form of this monetary policy framework. The increasing attraction of inflation targeting among EMs as a monetary policy framework combined with the salient characteristics of EMs has, in turn, stimulated much discussion about the role of the exchange rate in inflation targeting regimes.

More specifically, it is argued that emerging market economies are often beset by a lack of credibility and limited access to international markets; they are beset by more pronounced adverse effects of exchange rate volatility on trade, high liability dollarization, and higher pass-through from the exchange rate to inflation.[1] Consequently, it is argued that *benign neglect* of the exchange rate is not a feasible option for emerging market economies.

This, in turn, begs the following question: How should policymakers take account of the exchange rate under IT? It is true that under IT the credibility of the regime entails an institutional commitment to price stability since under this regime other goals—including the exchange rate—are subordinated to price stability. Monetary authorities in EMs, however, may need to take exchange rate movements into consideration for at least two reasons. First, the evolution of the exchange rate has an important impact on inflation owing to the open nature of EMs. Second, the presence of a thin foreign

[1] Calvo (1999).

exchange market or temporary shocks in EMs often forces these countries to dampen short-term exchange rate volatility.

As a consequence, EMs often resort to intervening or adjusting interest rates to contain the effect of temporary exchange rate shocks on inflation and financial stability.[2] In practice, it appears that all inflation targeting central banks explicitly allow for the option of intervening in foreign exchange markets, although industrial countries have rarely relied on this option in recent years (see Appendix). Indeed, evidence suggests that EMs, which typically have thinly-traded securities, engaged in foreign exchange interventions more frequently compared to industrial countries since the former are more vulnerable to disturbances stemming from the foreign exchange market (Carere et al., 2002).

Responding too heavily and too frequently to movements in the exchange rate under IT, however, runs the risk of transforming the exchange rate into a nominal anchor for monetary policy that takes precedence over the inflation target. One possible way to avoid this problem for inflation targeting central banks in EMs is to adopt transparent mechanisms that would ensure that polices to influence the exchange rate are aimed at smoothing the impact of temporary shocks and achieving the inflation objective.

Granted that central banks adopt such mechanisms, can they really mitigate unwarranted short-run exchange rate fluctuations? In the context of the IT framework, this study aims to shed more light on this issue by considering the experiences of Mexico and Turkey under the floating regime. To this end, the paper attempts to model central bank intervention and its effect on volatility using autoregressive conditional heteroscedasticity models. In particular, the study employs Nelson's (1991) Exponential-

[2] See Goldstein (2001) and Mishkin and Schmidt-Hebbel (2001) for more on this.

GARCH model, which allows for the inclusion of negative values as exogenous shocks in the variance, with a view to study the impact of sale and purchase operations separately in the analysis.

The empirical findings suggest that both the amount and frequency of foreign exchange interventions have decreased the volatility of the exchange rates in the countries under consideration. The results imply that sale operations are effective in influencing the exchange rate and its volatility, while purchase operations are found to be statistically insignificant in affecting the exchange rate and its volatility. All in all, the findings lend support to the notion that if foreign exchange interventions are carried out with finesse and sensibly—i.e., not to defend a particular exchange rate—they could play a useful role under an IT framework in mitigating the adverse effects of temporary exchange rate shocks on inflation and financial stability.

The remainder of this paper is organized as follows. The next section provides a brief overview of the literature on central bank intervention. Section 3 discusses the key aspects of the intervention mechanisms in Mexico and Turkey under the floating exchange rate regime. Section 4 describes the empirical framework to model conditional volatility and the effect of central bank interventions. Section 5 presents the empirical results. Section 6 concludes the paper.

2. A Brief Review of the Literature on Central Bank Intervention

This section briefly reviews the literature on central bank intervention. Empirical studies and statements by central banks suggest that central banks intervene in foreign exchange markets to slow or correct excessive trends in the exchange rate, i.e. they "lean

against the wind," and to calm disorderly markets (Lewis 1995; Baille and Osterberg 1997). The channels through which a non-sterilized intervention in the foreign market may affect the exchange rate are well known in the economic literature.[3] A purchase of dollars from the Central Bank may depreciate the underlying currency in the same proportion as the increase in liquidity on the money market and vice versa.

Sterilized intervention, on the other hand, might affect the exchange rate not through changes in liquidity, but through two main channels: portfolio balance and signaling. The portfolio balance channel assumes that investors diversify based on mean variance analysis.[4] As long as foreign and domestic bonds are imperfect substitutes, sterilized interventions, which alter the relative supply of local bonds, will always induce a change in the composition of the investor's portfolio. Investors will then require a greater (lower) return—measured by a risk premium—to absorb the increased (lower) supply of such instruments and this, along with an equal-amount-of-increase in the demand for foreign bonds, will cause a depreciation (appreciation) of the exchange rate.

Since interventions are small relative to the stock of outstanding bonds, most authors, including Rogoff (1984), have expressed skepticism that interventions could have a large impact through the portfolio balance channel. Not surprisingly, many studies do not find evidence of this channel and those that do, such as Evans and Lyons (2001) and Ghosh (1992), suggest it is weak.

The signaling channel refers to the signals sent by the central bank to the market. More specifically, if the central bank uses foreign exchange interventions credibly to

[3] For a more thorough review of the literature see Sarno and Taylor (2001), Dominguez and Frankel (1993b), and Edison (1993).

[4] A detailed analysis and description of the portfolio effect can be found in Domínguez and Frenkel (1993a).

indicate intended changes in monetary policy, the resulting appreciation of the exchange rate can be described as the signaling channel. The policy intentions or beliefs of the authority with respect to the foreign exchange market are made explicit with the aim of stabilizing or re-directing the market. Even in the case where such intentions are never realized, the exchange rate may change as a result of changing expectations about fundamentals.

The impact of intervention through the signaling channel has often been found to be substantially stronger than through the portfolio balance channel (Dominguez and Frankel (1993a)). For the signaling channel to be an ongoing transmission mechanism, central banks should be seen to follow interventions with appropriate changes in monetary policy. Consequently, interventions operating through the signaling channel do not constitute an independent policy tool.[5]

3. A Quick Glance at the Key Aspects of Foreign Exchange Intervention Policies in Mexico and Turkey

3.1 The Central Bank of Mexico

In the face of balance of payments and financial crisis, the Central Bank of Mexico could no longer defend the predetermined parity and decided to float the peso on December 19, 1994. With the adoption of the floating regime, the management of monetary aggregates became the anchor for the evolution of the general price level by early 1995. During the first half of 1995, however, the authorities modified this ruled-

[5] A recent study on Mexico, which aimed at investigating the portfolio and signaling effect, indicated that dollar purchases through the options mechanism have not significantly affected the foreign exchange market (Werner (1997b)).

based strategy centered solely on quantitative targets by incorporating discretion (via influencing the level of interest rates) in the conduct of monetary policy. Under the new strategy, discretion was constrained by the following ultimate goal: the attainment of the annual inflation objective, and in the medium to long run, the gradual reduction of inflation. This framework was maintained until 1997 and thereafter the monetary policy framework began a gradual transition toward an explicit, full-fledged, inflation targeting regime. As a consequence, the monetary base became less relevant and the inflation target more significant in the implementation of monetary policy. The Central Bank announced a series of annual inflation targets in 1999 with a view to converge to the inflation rate prevailing in the country's main trading partners. From this year on, the actual annual rate of inflation has been below the ceilings and the Central Bank expects to attain its final goal of a stationary annual inflation target of 3 percent by 2003. [6]

Although it is no longer the anchor of the economy, the role of the exchange rate as an adjustment variable in the conduct of the monetary policy still remains crucial. The intensity of pass-through shocks on inflation and output levels (and volatility) hinge on the relative stability of the exchange rate, which, by and large, lies behind the policies of sterilized foreign exchange rate intervention. Such stabilization has presumably relied more on the effectiveness of U.S. dollar (USD) sales in the foreign exchange market than to USD purchases, which have been mainly utilized to increase the amount of international assets.

[6] See Schmidt-Hebbel and Werner (2002) for more on this.

In August 1996, the authorities decided to auction put options[7] on the last business day of each month, giving the right to credit institutions of selling dollars to the Central Bank of Mexico on any day during the life of the contract as long as the exercise price (determined a day earlier) is no greater than the 20 day moving average of the fix exchange rate.[8]

Figure 1 presents the cumulative net purchases of USD since August 1996. By the end of the Put Options program in June 2001, international reserves represented 30% of the 40,866 million dollars. In total, market conditions allowed the participants to exercise the derivative instruments 132 times. Although there is no a clear policy of international reserve holdings, from the authorities' standpoint, this amount of foreign currency seems to be sufficient to insure the floating of the peso against capital flight or sudden shocks to the capital account.

Figure 1. Banco de Mexico's cumulative purchases of dollars[a]

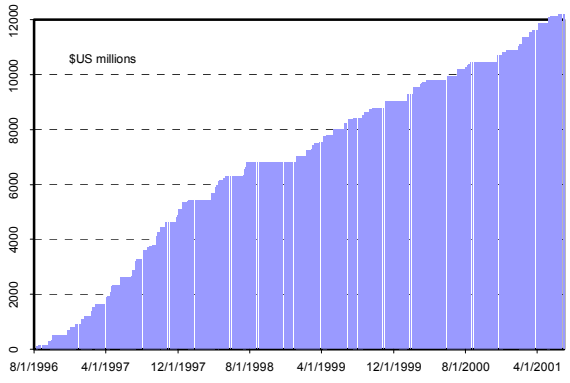
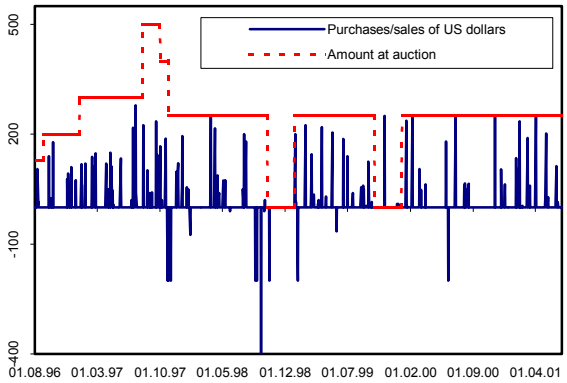


Figure 2. Daily purchases and sales of US dollars[b]



a: 1st August 1996 – 29th June 2001; b: August 1996 – June 2001 (maximum amount at auction in dotted lines).

The discontinuation of the Options Program may be attributed to the increasing concerns related to balance sheet currency mismatches. The bank assets returns (priced

[7] This section provides a brief description of the derivatives mechanism. A more comprehensive discussion of this issue can be found in Werner and Milo (1998).

[8] The *fix exchange rate* is the exchange rate used by credit institutions in Mexico to settle transactions denominated in foreign currency and to be liquidated within the country.

in dollars) have been lower with respect to the interest paid for government instruments denominated in local currency—a situation that worsens in episodes of excess demand for pesos. In addition, there could be *funding risks* associated to the different maturity dates of both assets and liabilities.

In addition to keeping some symmetry in the intervention policy, internal and external destabilizing shocks have been controlled by daily auction sales of US$ 200 million in a formal program of contingent sales of dollars since February 1997.[9] Figure 2 shows the magnitude and frequency of the USD sales and purchases in millions with the auction amounts denoted by the lines. It is interesting to note that the amount of sales during the period under investigation, with 14 interventions by the Central Bank of Mexico, reached only USD 2,100 million.

All in all, the main goal of the Put Options program has been the accumulation of international reserves, whereas contingent sales of dollars have been activated in periods of high volatility and liquidity contractions.[10] The authorities have made it clear that both Put Options and contingent sales are not intended to affect or defend a particular exchange rate.

3.2 The Central Bank of Turkey

On February 22, 2001, Turkey announced its intention to float the lira, after following a quasi-currency board/crawling peg exchange rate regime for over a year, as part of its economic reform program. During the peak period of the crisis—the first

[9] Before this program, during the crisis of 1995, an additional USD5 billion were sold to compensate the amortization of TESOBONOS and some commercial bank's credit lines (Schmidt-Hebbel and Werner (2002)).

[10] However, the Annual Report for 1998 acknowledges that contingent sales may in fact worsen volatility during liquidity contractions (see page 130).

phase of forex operations—the priority of the Central Bank was to ensure the integrity of the payment system and keep potential systemic risks under control. Foreign exchange sales were conducted with a view to assist the banking system to cover its foreign exchange short position and to enable banks to pay their foreign currency-based liabilities. Timing, total volume and value of sales were decided in accordance with market fluctuations, payment default risks and the daily sentiment of the market players. Other than direct sales, foreign exchange swaps have also been utilized under appropriate conditions.

A new IMF supported economic program, which was launched in May 2001, marked the third phase of forex operations. Under this program, pre-announcements of auctions were paused; and instead of daily base operations, sales have been decided according to daily market conditions. Additionally, it was decided that the total sale amount would not be announced before the auction and the final decision was given in accordance with total demand and daily market movements.

The excess Turkish lira liquidity in the market, which was injected as a result of the utilization of the IMF and World Bank credits for Turkish lira payments by the Treasury, was mopped up by the programmed and scheduled foreign exchange sale auctions. Contrary to earlier phases during which the aim was to support the banking system, in this phase the Central Bank used forex operations as part of liquidity management policies.

During July 2001, pre-announced auction figures remained within the minimum levels, so that the Central Bank had the option to increase the amount to be sold if the need were to emerge. Moreover, instead of one auction per day, auctions were placed on

certain dates, with around two auctions per week. Daily auctions were put back in place in September 2001 with a daily sale amount of USD 20 million and were continued through November. However, these pre-announced auctions were paused in December 2001, as the Treasury did not plan to use additional external funding for the purpose of domestic payments.

The fourth phase of forex operations was determined by the Central Bank's decision to increase the level of foreign exchange reserves through foreign exchange buying auctions. However, as was the case with the pre-announced and pre-scheduled auctions, there was no targeted level of reserves to be achieved. The aim was to enhance the level of foreign exchange reserves without creating additional volatility in the foreign exchange rates and without disturbing the banks' foreign exchange positions.

The Central Bank resumed holding daily foreign exchange buying auctions in the amount of USD 20 million during June 2002 as well. During this month, 20 foreign exchange buying auctions were scheduled, so that the maximum amount of foreign exchange to be bought through these auctions would not exceed USD 400 million. However, the Central Bank decided to suspend the foreign exchange buying auctions temporarily from July 1, 2002, in view of the reduced volume of the transactions and increased political uncertainty prior to early elections in November 2002.

4. Modeling Volatility and Central Bank Intervention

A recent wave of studies on the effects of central bank intervention on the volatility of the exchange rate has relied on the stylized Generalized Autoregressive

Conditional Heterosledasitcity (GARCH) models.[11] For instance, to analyze the effect of the Deutsche Bundesbank and the Central Bank of Japan on the volatility of the mark and the yen respectively, Dominguez (1998) uses the parsimonious GARCH(1,1) model of Bollerslev (1986). In an attempt to avoid violating non-negativity conditions, Dominguez (1998) includes the absolute value of sales and purchases as exogenous variables in the variance equation. This transformation, however, does not allow the investigation to distinguish the effect of sales (expressed in negative magnitudes) on the conditional variance adequately. Instead, the study focuses on the overall effect of intervention.

Recent studies for the above-mentioned currencies suggest that traditional GARCH models are outperformed by fractionally integrated or long-memory processes and tend to underestimate the intervention effects in terms of volatility.[12] In their study on the Bank of Australia's intervention operations and its effect on exchange rate volatility, Kim, *et. al.* (2000) employ the Exponential-GARCH (E-GARCH) model of Nelson (1991). The E-GARCH allows for the inclusion of negative variables affecting volatility, which, in turn, makes it possible to analyze the components of the intervention operations—i.e., sales and purchases as well.

In this paper, we also follow this approach to analyze both the overall effect of intervention and the individual effect of sales and purchases. More specifically, we

[11] In the case of Mexico an alternative approach would consist in analyzing the implied volatility of option prices. The main practical limitation, however, is the lack of information on a daily basis.
[12] See for instance (Beine, *et. al.* (2002)).

propose the following process to model exchange rate returns and conditional volatility assuming that the error terms are drawn from a double exponential (DE) distribution:[13]

$$
\begin{aligned}
& r_t = \phi_0 + \phi_{\text{int}\,er} INTER + \phi_{sales} SALES + \phi_{purchs} PURCHS + \phi_{sign} SIGN \\
& + \phi_{brady} BRADY + \phi_{ON} ON + \varepsilon_t; \quad \varepsilon_t \sim DE(0, \sigma_t^2), \quad \varepsilon_t = e_t \sigma_t, \quad e_t \sim iid(0,1) \\
& \ln(\sigma_t^2) = w + \alpha(|e_{t-1}| + \gamma e_{t-1}) + \beta \ln(\sigma_{t-1}^2) + \delta_{\text{int}\,er} INTER + \delta_{sales} SALES \\
& + \delta_{purchs} PURCHS + \delta_{sign} SIGN + \delta_{brady} BRADY + \delta_{ON} ON
\end{aligned}
\tag{1}
$$

where INTER, SALES, PURCHS stand for, all in millions of USD, central bank intervention, sales of foreign exchange, and purchases of foreign exchange, respectively.[14]

SIGN is a dummy variable with a value of unity on the day of a public report, and is intended to signal exchange rate policy intentions on dates where there was a modification of the contractual terms of the auctions. Information on this variable is recorded from the central banks monetary reports, annual reports and press releases.

In an attempt to directly account for the effect of intervention in the money market, we include the policy instrument for each country, denoted as ON. For Mexico, we use the actual daily stance or target for cumulative balances in millions of pesos,

[13] A preliminary analysis suggested the use of the Generalized Error Distribution (GED). The estimated tail thickness parameter (ν) could not reject the hypothesis Ho: ν= 1, which corresponds to the Laplace distribution whose distribution function is $f(x) = e^{-|x|}/2$. In addition, Akaike and Bayes criteria preferred this conditional density over a GED, normal or *t* distributions. This analysis is not included in the paper, although the results are readily available upon request.

[14] In the case of Mexico, given that investors will decide to exercise the put options in appreciating trends, Werner (1997b) noticed that the variable PURCHS cannot be an exogenous variable since it is correlated with the error term (ε_t) in equation (1). In order to address the inconsistency problem, he uses the two period lag of the variable as instrumental variable. In this paper, we also follow this approach (see Werner (1997b) for more details).

whereas for Turkey the annualized first difference of the overnight interest rate is employed.

Werner (1997b) has reported a very strong association between the international price for debt and the exchange rate process in Mexico. In light of his finding, we include the first difference of the Brady bond yields, denoted as BRADY.

To examine the effects of central bank intervention in frequency terms, that is, to study the response of the variance to the number of times the institution sells or buys at the same time, we include dummy variables taking a value of one for every purchase and minus one for every sale of dollars in the market, and zero in the case of no sales or purchases. In other words, INTER takes a value of unity when net purchases of dollars (the sum of buys and sells) are positive, minus one when they are negative, and 0 otherwise. PURCHS will take a value of one when there is a purchase of dollars and zero otherwise, while SALES takes a value of minus one for every sale of dollars.

The parameter α in the variance equation emulates the clustering effect showed by traditional GARCH models, whereas γ is a leverage parameter allowing the variance to respond differently following equal magnitude negative or positive shocks. Volatility persistence is measured by β under the restriction that the estimate is smaller than one to avoid an explosive behavior of the variance.

To examine the asymmetric response of the variance to positive and negative innovations, we employ the News Impact Curve (NIC) by Engle and Ng (1993), which is defined as:

$$NIC(\varepsilon_t \mid \sigma_t^2 = \sigma^2) = \begin{cases} A\exp\left(\dfrac{\alpha\gamma + \alpha}{\sigma}\right) \text{ for } \varepsilon_t > 0 \\ A\exp\left(\dfrac{\alpha\gamma - \alpha}{\sigma}\right) \text{ for } \varepsilon_t < 0 \end{cases} \tag{2}$$

$$A = \sigma^{2\beta}\exp(w - \alpha\sqrt{2/\pi})$$

Finally, to account for day of the week effects, we tested the significance of dummy variables. The associated coefficients turned out to be individually and jointly not different from zero.[15]

5. Data Description and Estimation Results

5.1 Data Analysis[16]

Daily exchange rate returns are calculated by taking the log difference of the US dollar/ Mexican peso ($US/MXP) exchange rate from August 1, 1996 to June 29, 2001 and of the US dollar/Turkish lira ($US/TL) from February 22, 2001 to May 30, 2002, respectively. For Mexico, we use the exchange rate determined in the 48 hour inter-bank foreign exchange market.[17] In the case of Turkey, we employ the selling spot rate.

Table 1 shows descriptive statistics for the exchange rate log returns, the first difference of the Brady bond yields in Mexico, the target for cumulative balances (or *short*) in millions of pesos, and the first difference of the overnight interest rate in Turkey.

Table 1. Descriptive statistics on exchange rate log-returns and money market.

[15] We do not report such estimators on the grounds of parsimony, though the results can be obtained from the authors upon request.

[16] All data are obtained from the Banco de Mexico and the Central Bank of the Republic of Turkey except for Brady par yield, which is taken from Datastream (mnemonics MXBSYLD).

[17] We also used the spot floating exchange rate and the results are basically equivalent.

	$\bar{x}$	σ	S[a]	K[b]	SW[c]	Min.	Max.	N
US$/MXP	-0.0061[d]	0.0026	-1.6018	19.43	0.8285*	-0.0243	0.0155	1,282
US$/TL	-0.0969[d]	0.0119	5.6253	67.41	0.6564*	-0.1454	0.0546	317
BRADY[e]	-0.0033	0.3229	-0.1581	17.16	0.7933*	-3.0400	2.3700	1,282
ON[f]	-12.525	164.31	16.0202	267.88	0.0802*	-2,823.3	4.0000	317
Short[g]	-130.40	128.00	-0.6873	-0.6063	0.8362*	-400	0	1,282

*Reject the null at the 1% level. [a] S=Skewness; [b] K=Kurtosis; [c] SW= Shapiro-Wilk test for normality; [d] Numbers multiplied by 100; [e] BRADY is the first difference of the Mexican brady bond; [f] ON is the first difference of the overnight Turkish interest rate and [g]Short is the Target for Cumulative Balances in Mexico in millions of Pesos.

Log-returns present excess kurtosis and significant departures from normality as indicated by the Shapiro-Wilk test. The distribution of the Turkish lira is biased to the right, and the peso to the left.

Figure 3: US$/MXP exchange rate[a]

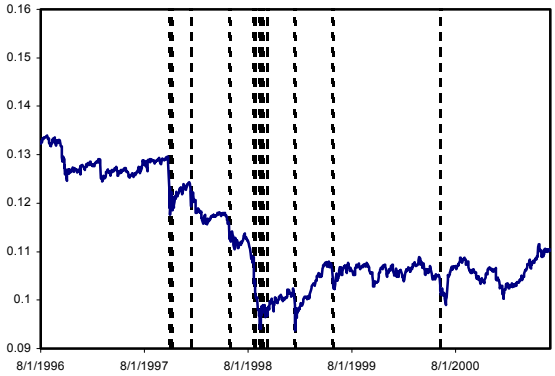


Figure 4: US$/MXP exchange rate returns[a]

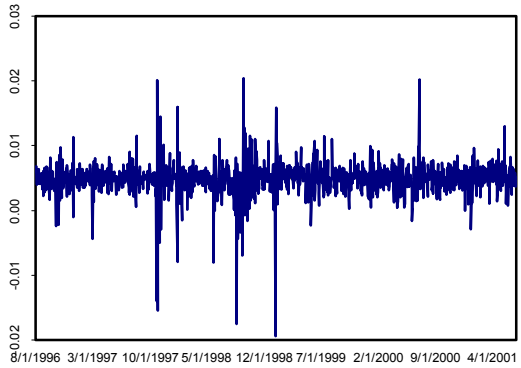


Figure 5: US$/TL exchange rate[b]

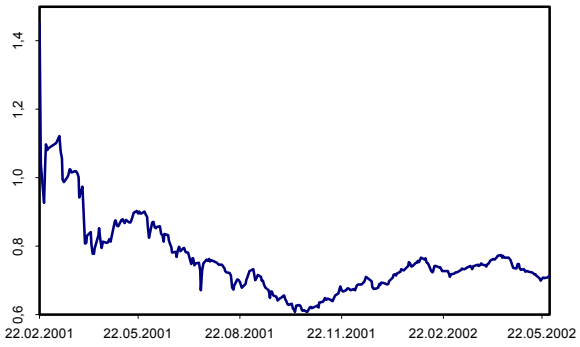
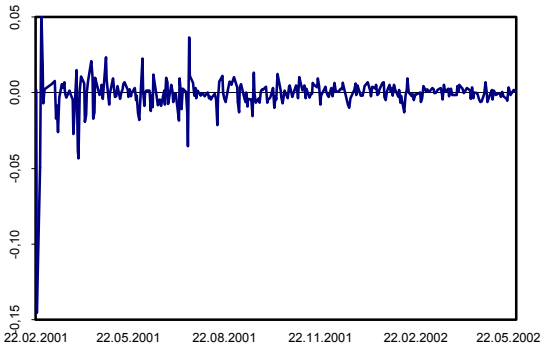


Figure 6: US$/TL exchange rate returns[b]



a: August 1996–June 2001, contingent sales in vertical lines; b: 22 February 2001– 29 May 2002.

Table 2 presents the results of the Augmented Dickey-Fuller and Phillips-Perron tests for unit roots. The findings of both tests show that log-returns of the peso and lira can be treated as stationary variables.

Table 2. Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) unit root tests [a]

	ADF		PP	
Currency	(5)	(20)	(5)	(20)
US$/MXP	-15.19*	-7.52*	-37.29*	37.26*
US$/TL	-8.07*	-3.76*	-15.09*	-15.11*

* Significant at the 1% level. [a] The order of augmentation is in parenthesis and the tests include a drift term.

Table 3 displays statistics on the Central Bank of Mexico daily foreign exchange market intervention. The average amount of put options at auction was USD 235.8 million. To put this into context, it is comparable to the mean sales or purchases of dollars carried out by the U.S. Federal Reserve Bank during the period 1977 to 1994. The average amount of exercised options was, however, USD 9.6 million.

The amount and frequency of contingent sales is substantially smaller than that of purchases. There was a sale of dollars every 100 working days of about USD 1.7 million on average. The maximum amount of USD sales is 200 million, which took place on September 10, 1998, and is almost equivalent to the highest amount of exercised options. On that day, there was also a USD 278 million discretionary and unanticipated sale of dollars.

Table 3. Statistics of foreign exchange daily intervention in Mexico, August 1996-June 2001.

	Average Amount (m.d.)	Dispersion (m.d.)	Max. (m.d.)
Put Options	235.8	97.10	500
Exercised Options	9.6	37.03	279
Sales	1.7	17.36	200

The dotted lines in Figure 3 with the $US/MXP spot exchange rate and Figure 4 with log exchange rate returns from August 1996 to June 2001 show the points at which there were contingent sales of dollars, which mainly occurred during high volatility periods and seemed to be followed by currency appreciations.

In general, one may say that the magnitude and frequency of interventions in Mexico, which declined noticeably since 1999, are in line with the experience of other countries that practice floating with varying degrees of "dirt".[18]

5.2 Estimation Results

This section aims to assess whether central bank interventions both in frequency and magnitude have any impact on the evolution of the exchange rate and its volatility. To this end, Tables 4 and 5 report the empirical results pertaining to the overall and individual central bank intervention effects on the conditional mean and variance.[19,20] The first two columns corresponding to each country present the E-GARCH parameter estimates with exogenous shocks measured in magnitudes and frequencies, respectively. The column labeled restricted in Table 5 for each country shows the basic model with no intervention effects, that is $\phi_{inter}=\phi_{purch}=\phi_{sales}=\phi_{sign}=\phi_{brady}=\phi_{on}=\phi_{put}=0$ in both the mean and variance equations.

Diagnostics and decision criteria are presented at the bottom of the tables. Akaike and Bayes criteria select a parsimonious random walk plus drift to model the mean

[18] In the real world clean floats do not exist. Even the US, usually regarded as the cleanest of the floaters, intervenes occasionally in the foreign exchange market. In the case of Mexico, the majority of sale interventions were associated with the pressures exerted by the Zamba and Russian crises during 1998.

[19] The overall effect of interventions is studied by setting $\phi_{purch}=\phi_{sales}=0$ in equation (1). The individual impacts are analyzed by constraining $\phi_{inter}=0$ in the same equation.

[20] The lag structure in the estimations is determined by the Bayesian and Akaike information criteria.

exchange rate returns of both currencies.[21] Ljung-Box statistics for the presence of autocorrelation in the standardized residuals and in the squares of the standardized residuals cannot reject the null at conventional levels.[22]

5.2.1 Mean Equation

We first examine the exchange rate mean level. According to our estimates, overall intervention operations during the floating regime have had a highly significant positive impact on the exchange rates, as can be seen from ϕ_{inter} in Table 4. A net sale of USD 100 million in Mexico appreciates the exchange rate by 0.08 percent, whereas in Turkey a similar operation appreciates the lira by 0.20 percent.

As can be seen from Table 4, the results show that both the size and the frequency of central bank interventions in the market exert a positive pressure on the foreign exchange—i.e. appreciation. More specifically, our findings imply that whenever the exchange market perceives the presence of the central bank, the Mexican peso and the Turkish lira appreciate by 0.12 percent and 0.09 percent, respectively.

[21] In the case of Mexico, this is in line with Werner (1997a) and Werner (1997b). The difference of local and foreign interest rates was also considered as a regressor; however, this variable became statistically insignificant in both countries once departures from normality are taken into account.

[22] The exception is net intervention measured in frequencies for Turkey presented in Table 5 where the introduction of qualitative dummies somehow induces heteroskedasticity. To deal with potential model misspecification we calculated robust *t-ratios* using the Quasi Maximum Likelihood method suggested by Bollerslev and Wooldridge (1992). The results, available from the authors, are consistent with the original findings and basically confirm the conclusions.

Table 4. EGARCH(1,1) Estimations: Net Foreign Exchange Central Bank Intervention in Mexico and Turkey.

	Mexico			Turkey		
	Magnitudes[a]	Frequencies	Restricted	Magnitudes[a]	Frequencies	Restricted
Mean Equation						
ϕ_o	-0.00008***	-0.00014*	-3.54e-09	0.00044***	-0.00003	0.000001
	(-1.6101)[b]	(-2.8403)	(-9.9e-07)	(1.9429)	(-0.1441)	(0.03728)
ϕ_{inter}[c]	8.3e-06*	0.00117*	_	0.00002*	0.00085*	_
	(13.636)	(15.4138)		(3.8514)	(3.0779)	
ϕ_{sign}	-0.00005	-0.00020	_	0.0009	0.00203	_
	(-0.1197)	(-0.43317)		(0.06246)	(1.6462)	
ϕ_{brady}	-0.00062*	-0.00058*	-0.00061*	_	_	_
	(-4.5418)	(4.3338)	(-4.3340)			
ϕ_{ON}[d]	3.13e-07	4.39-07***	_	-4.3e-07	5.9e-07	_
	(1.2132)	(1.7177)		(-0.0050)	(-0.0065)	
Variance Equation						
ω	-1.8810*	-2.2050*	-1.6680*	-2.9820*	-3.4460*	-0.3239*
	(-7.2810)	(-7.9162)	(-6.8440)	(-2.8189)	(-2.7182)	(-2.5764)
α	0.2246*	0.2482*	0.2338*	0.4907*	0.5961*	0.1489*
	(5.4018)	(5.1337)	(5.5630)	(2.7391)	(3.3950)	(3.3351)
β	0.8617*	0.8371*	0.8799*	0.7502*	0.7076*	0.9796*
	(43.0238)	(39.4554)	(46.7700)	(7.6158)	(5.9962)	(85.2927)
γ	-0.9467*	-0.8697*	-0.9933*	_	_	_
	(-4.3584)	(-3.8704)	(-4.4210)			
δ_{inter}	-0.00373*	-0.6018*	_	-0.00329**	-0.2536**	_
	(-6.8121)	(-6.9585)		(-2.2635)	(-2.1041)	
δ_{ON}	0.00014	0.00013	_	-0.00204*	-0.00199	_
	(1.4113)	(1.2007)		(-1.6208)	(-1.5600)	
δ_{sig}	0.4965***	0.5761**	_	0.2222	-0.1057	_
	(1.7702)	(2.1004)		(0.2064)	(-0.1004)	
δ_{put}	-0.00008	_	_	_	_	_
	(-0.55512)					
Decision Criteria						
AIC[e]	-12,582.7	-12,625.5	-12,491.1	-2,317.6	-2,309.8	-2,277.3
BIC[e]	-12,505.4	-12,553.4	-12,460.1	-2,280.0	-2,272.2	-2,262.3
$Q_\varepsilon(20)$[f]	22.00	25.08	23.79	16.40	17.64	12.88
	[0.3405][g]	[0.1984]	[0.2517]	[0.6915]	[0.6111]	[0.8824]
$Q^2_\varepsilon(20)$[f]	9.55	11.11	7.88	14.97	31.96	0.46
	[0.9756]	[0.9433]	[0.9926]	[0.7781]	[0.0437]	[0.9999]

*, ** and *** denote significance at the 1, 5 and 10% levels respectively. [a] In millions of US dollars; [b] *t-ratios* in parenthesis; [c] Net intervention is measured as the sum of sales and purchases in a given day; [d] ON denotes the target for cumulative balances (*short*) in Mexico and the overnight interest rate in Turkey; [e] AIC and BIC are the Akaike and Bayes Information Criteria respectively; [f] $Q_\varepsilon(20)$ and $Q^2_\varepsilon(20)$ are the twentieth-order Ljung-Box tests for correlation in the standardized residuals and in the squares of the standardized residuals; [g] P-values in brackets.

In Table 5, we present the effect of intervention on the exchange rate by type of operations. A sale to the market of USD 100 million appreciates the peso by 0.90 percent, while an equivalent intervention in Turkey appreciates the lira by 0.20 percent. Similarly, for every presence of the central banks, the peso and the lira appreciate by 1.3

percent and 0.16 percent, respectively. By contrast, purchases of dollars are generally not statistically different from zero, suggesting that sterilized interventions of this nature do not influence the exchange rate mean level.

Table 5. EGARCH(1,1) Estimations: Central Bank dollar sales/purchases in amounts and frequencies.

	Mexico		Turkey	
	Magnitudes[a]	Frequencies	Magnitudes[a]	Frequencies
Mean Equation				
ϕ_o	9.5e-09	4.8e-09	0.00033	0.00051
	(0.0003)[b]	(0.0010)	(1.2560)	(1.4792)
ϕ_{sales}	0.00009*	0.01279*	0.00002*	0.00158*
	(9.0397)	(8.5266)	(3.2444)	(2.7893)
ϕ_{purchs}	4.8e-07	6.6e-05	0.00003	0.00001
	(0.5829)	(0.6227)	(1.4543)	(0.0049)
ϕ_{sign}	-0.00039	0.00009	0.00209	0.00215
	(-1.0345)	(0.2464)	(1.2576)	(1.5071)
ϕ_{brady}	-0.00071*	-0.00078*	–	–
	(-5.0664)	(5.5539)		
Variance Equation				
ω	-1.6150*	-1.8440*	-2.7575*	-3.4023*
	(-5.2121)	(-5.4996)	(-2.9329)	(-2.9118)
α	0.14480*	0.14820*	0.4706*	0.5889*
	(3.1443)	(3.0129)	(2.7800)	(3.4734)
β	0.8797*	0.8661*	0.7708*	0.7193*
	(36.5108)	(34.0331)	(8.8436)	(6.6930)
γ	-1.0000**	-1.0000**	–	–
	(-12.3337)	(-2.3134)		
δ_{sales}	-0.01091*	-2.1930*	-0.00308**	-0.3419***
	(-5.5154)	(-4.9335)	(-2.2545)	(-1.7891)
δ_{purchs}	0.00153***	0.03651	-0.00169	-0.1116
	(1.7611)	(0.3482)	(-0.2805)	(-0.3771)
δ_{ON}[c]	0.00023*	0.00025*	-0.00167*	-0.0018*
	(2.7190)	(2.6158)	(-4.0173)	(-3.7717)
δ_{sig}	-0.03104	0.1347	0.17198	-0.0405
	(-0.0895)	(0.3526)	(0.1657)	(-0.03897)
δ_{put}	-0.00026**	–	–	–
	(-1.9518)			
Decision Criteria				
AIC[d]	-12,556.8	-12,578.2	-2,316.8	-2,310.6
BIC[d]	-12,474.3	-12,500.9	-2,275.5	-2,269.2
$Q_\varepsilon(20)$[e]	23.99	24.52	15.56	15.75
	[0.2428][f]	[0.2204]	[0.7435]	[0.7320]
$Q^2_\varepsilon(20)$[e]	4.61	13.37	14.60	28.87
	[0.9998]	[0.8610]	[0.7988]	[0.0904]

*, ** and *** denote significance at the 1, 5 and 10% levels respectively. [a] In millions of US dollars; [b] *t-ratios* in parenthesis; [c] ON denotes the target for cumulative balances (short) in Mexico and the overnight interest rate in Turkey; [d]AIC and BIC are the Akaike and Bayes Information Criteria respectively; [e] $Q_\varepsilon(20)$ and $Q^2_\varepsilon(20)$ are the twentieth-order Ljung-Box tests for correlation in the residuals and in the squares of the residuals; [f] P-values in brackets.

The results also suggest that monetary policy instruments and signals to the market— estimates of ϕ_{ON} and ϕ_{sign}—do not seem to affect the direction or magnitude of the mean exchange rate.[23] Finally, in line with the findings of Werner (1997b), an increase in the international price for debt is associated with the depreciation of the Mexican peso.

5.2.2. Variance Equation

We next turn to the effect of overall and disaggregated central bank intervention on the conditional variance. As indicated by Dominguez (1998), central bank intervention is expected to reduce volatility as long as it signals a commitment to reduce volatility and intervention is both credible and unambiguous.

From the estimated parameters (δ_{inter} in Table 4), we observe that overall central bank intervention has significantly decreased the conditional variance of both the Mexican peso and the Turkish lira. In this respect, it may be useful to make a distinction between the size and frequency of the interventions in terms of their impact on the volatility of the exchange rate. The response of volatility to the magnitude of intervention is very similar in both countries. The impact of the frequency of intervention on the volatility of the exchange rate, however, is greater in the case of Mexico compared to Turkey.

When the impact of interventions is studied separately, the results, once again, show that the reduction of volatility is a direct result of sales and not purchases of dollars (Table 5). Indeed, the findings demonstrate that dollar sales—both in size and

[23] The ϕ_{ON} estimates are not reported in Table 5 to save space.

frequency—have a strong negative impact on the volatility of the exchange rate, while the impact of purchases on the volatility of the exchange rate turns out to be positive but statistically insignificant.[24,25]

In line with the findings of Kim, *et. al.* (2000), exchange rate volatility in Mexico has been at best weakly positively influenced by the signaling effect (δ_{sign} in Table 4). The results suggest that official reports, signaling modifications in the policy of intervention, have not had a significant effect on the conditional variance of the Turkish lira.

The empirical results also imply that changes in the monetary authorities' instrument have an impact on the conditional variance process. As can be seen from Table 5, changes in the policy instrument—short—have a positive impact on the volatility of the exchange rate (δ_{ON}) in Mexico.

In the case of Turkey, however, the results imply that an increase in the policy instrument—overnight interest rate—has a negative effect on the conditional variance of the exchange rate.[26] The negative impact exerted by the monetary policy instrument in Turkey suggests that interest rate intervention is possibly acting as a parallel stabilizing force, while in the case of Mexico empirical findings suggest that the target for cumulative balances has an adverse impact on the stability of the exchange rate market.

[24] There is, however, some weak evidence suggesting that the volatility of the peso increases with the magnitude of the purchase by 15 basis points (see δ_{purchs} in Table 5).

[25] These results are in clear contrast with the studies on hard currencies by Beine et. al (2002), Kim, et. al. (2000), Baillie & Oesterber (1997a,b) and Dominguez (1998), who find that exchange rate volatility is generally increased following a central bank intervention.

[26] Contrary to our findings for Turkey, Booth, *et. al.* (2000) report a positive association between interest rate changes and exchange rate volatility in their study of the effects of the Bundesbank's discount and Lombard's interest rate changes on the volatility of the DM exchange rate.

Finally, in the case of Mexico, we also find weak evidence suggesting that the size of the put options contracts reduces the volatility of the peso.

In the context of the floating regime, what can be concluded about the performance of forex interventions in these countries? As argued by Obstfeld (1995), clean floating means high volatility of the nominal exchange rate—much higher than early proponents such as Friedman (1953) and Johnson (1969) anticipated. Moreover, as Mussa (1986) points out, it almost always means greater volatility of the real exchange rate, for prices move sluggishly. To the extent that this volatility in real prices is costly, either directly or because it causes volatility in output or in the health of the financial system, policy makers typically want to mitigate it. This, in turn, could explain to a great extent the rationale for the intervention in the foreign exchange market in both countries. In this regard, results imply that central bank interventions both in Mexico and Turkey have been successful.

5.2.3 Clusters, Asymmetries and Persistency

As was discussed in section four, the conditional variance of the exchange rates might not only be affected by the magnitude of innovations and by past values of the conditional variance, as is the case in simple GARCH processes, but also by the direction of the shocks.

As can be gathered from Tables 4 and 5, the E-GARCH parameters with no exception are highly significant. Once we consider intervention, the decay rate (β) for Turkey is higher than that of Mexico. More specifically, a volatility shock to the peso's conditional variance reaches half its original size in four days as a minimum, while it

takes three days at most in the case of the lira.[27] Interestingly, our estimates suggest that shocks to volatility are less persistent when the central bank intervenes.

The conditional variance of the peso reacts differently to equal magnitude negative and positive innovations.[28] From the standpoint of the foreign investor, the response of the conditional variance would be greater to bad news (depreciations) than to good news (appreciations) of the same magnitude.

To examine the effect of central bank intervention on the sensitivity of the conditional variance of both currencies, we use the news impact curve (NIC) for the restricted EGARCH model (continuous line) introduced in section four.[29] As can be seen from Figure 7, the conditional variance of the peso reacts more to past negative shocks than to positive innovations of equal size. Moreover, the response is greater, the bigger the size of the shock. For the Turkish lira, such response is fully symmetric since the leverage effect turned out to be statistically insignificant.

The doted and discontinuous lines in Figure 7 also show the NIC for the extended models—i.e., considering intervention in frequencies and magnitudes respectively. They present the actual variance responses once the exogenous variables are taken into consideration. In general, the sensitivity of the conditional variance is greater than the one suggested by the restricted E-GARCH model with no exogenous influences (continuous line).[30]

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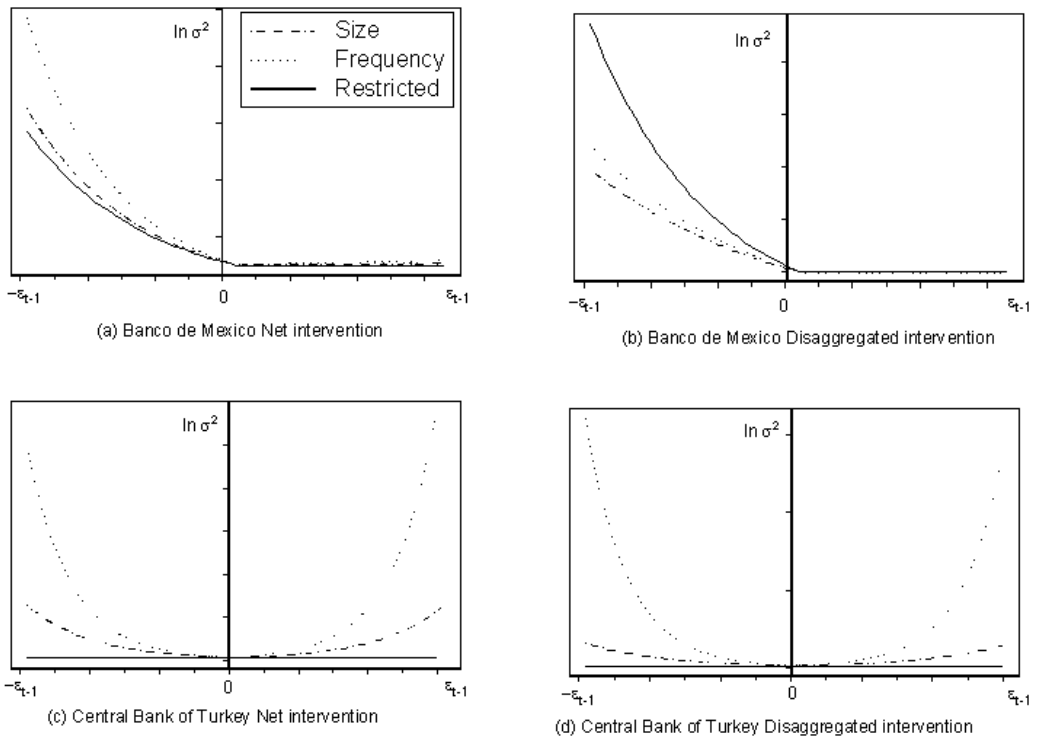
[27] This is the so-called half-life statistic indicating the number of days in which a shock to the variance reaches half its initial size. Here we calculate this as $\log(0.5)/\log(\beta)$.

[28] The leverage effect (γ) in Turkey was not significantly different from zero. Hence, in all the estimations for this country, we restrict such coefficient to zero in which case the responses of the conditional variance, as it is graphically shown, are fully symmetric.

[29] To keep comparability, we standardized all NIC curves by setting A=1.

[30] See also AIC and BIC in Tables 5 and 6.

Figure 7: News Impact Curve before and after foreign exchange intervention.



The existence of asymmetries in Mexico is a direct result of the stylized fact where depreciations are not just usually followed by high volatility episodes, but also such shocks affect more the conditional variance compared to appreciations of equal magnitude. In the money market, Mendoza (2002) has related asymmetries to the behavior of the exchange rate: sudden exchange rate depreciations may cause the volatility of the interest rates term structure to be higher than it would be following unexpected appreciations of the same size.

We believe that a similar reasoning lies behind the finding of asymmetries in the Mexican foreign exchange market. It is perhaps the exchange rate coordination with the

monetary policy that gives rise to different volatility responses. Sudden depreciations (bad news) would decrease the expected future holding returns of local investments, which, in turn, would increase the exchange rate volatility more than equal size appreciations (good news) given the investors' desire to get rid of excess local holdings.

6. Conclusion

The intrinsic problems of exchange rates in emerging market economies (EMs) coupled with the increasing adoption of inflation targeting (IT) in these countries has rendered the role of the exchange rate under an IT framework as one of the most frequently discussed topics in the relevant literature. It is argued that monetary policy in EMs tends to be more sensitive to exchange rate movements both directly—because of pass-through effects on inflation—and indirectly—because the exchange rate appears as an additional argument in central bank objective functions, reflecting their concerns for devaluation-induced bank failures and domestic recessions.[31]

As a result, central banks in EMs often resort to sterilized exchange rate interventions in response to large exchange rate shocks in order to contain the impact of pass-through effects on inflation and reduce excessive exchange rate volatility. This study aims at shedding more light on this issue by investigating whether central bank foreign exchange interventions have had any impact on the volatility of the exchange rate in Mexico and Turkey since the adoption of the floating regime. To this end, we employ an Exponential GARCH framework, which allows us to investigate both the overall effect of the intervention and the individual effect of sales and purchases.

[31] Schmidt-Hebbel and Werner (2002).

The results of the empirical investigation suggest that overall intervention operations during the floating regime in both countries has had a positive and statistically significant impact on the exchange rates. More specifically, empirical findings suggest that a net sale of USD 100 million appreciates the exchange rate in Mexico and Turkey by 0.08 percent by 0.20 percent, respectively. The empirical evidence also shows that the presence of the central bank matters: whenever the exchange market perceives the presence of the central bank, the Mexican peso and the Turkish lira appreciate by 0.12 percent and 0.09 percent, respectively.

As far as the individual impact of central banks' purchase and sale operations are concerned, the results suggest that a sale to the market of USD 100 million appreciates the peso by 0.90 percent, while an equivalent intervention in Turkey appreciates the lira by 0.20 percent. Similarly, in the presence of the central bank, the peso and the lira appreciate by 1.3 percent and 0.16 percent, respectively. By contrast, the results suggest that purchases of dollars are generally statistically insignificant, suggesting that sterilized interventions of this nature are not effective.

The empirical findings concerning the impact of overall intervention on the volatility of the exchange rate suggest that overall central bank interventions have reduced the conditional variance of both the Mexican peso and the Turkish lira.[32] When the impact of interventions is studied separately, the results, once again, show that the reduction of volatility is a direct result of sale operations. Purchase operations do not seem to have a statistically significant effect on the volatility of the exchange rate.

[32] The results suggest that the response of volatility to the magnitude of intervention is very similar in both countries. The impact of the presence in the market on the volatility of the exchange rate, however, is greater in the case of Mexico compared to Turkey.

There are two main policy implications emerging from the thrust of the overall findings. First, there seems to be scope for EMs to operate flexible exchange rate regimes without having to adopt a textbook type of pure float. In fact, it would be unreasonable to assert that EMs should adopt more pure forms of floating than the industrial countries have been able to sustain, particularly when the conditions necessary for a successful float are less likely to be present in such economies. [33]

Second, the fact that exchange rates, at times, move too far relative to fundamentals even in countries that pursue credible monetary and fiscal policy provides a legitimate role for intervention. In order to ensure the desired impact on expectations and the behavior of market participants, interventions should be based on transparent mechanisms and should be used sparingly.

There are obviously difficult practical issues regarding the operation of intervention. The intuitive idea as put forth by Volcker (1995), however, is clear enough—the further the actual exchange rate has departed from the equilibrium, the more damage the misalignment will do; the more confident the authorities can be that they will be acting as profitable stabilizing speculators (buying low and selling high); and the greater likelihood of success of any intervention on the part of the authorities.

The empirical findings and the above highlighted policy suggestions, which are based on the premise that intervention can be effective in smoothing short-term fluctuations in the exchange rate, do not suggest that policy intervention can be used to

[33] Evidence from a recent research by Hunt et. al. (2002), which argues that benign neglect of the exchange rate is not necessarily the best approach in the conduct of monetary policy under IT—particularly if risk premia are subject to shocks that cause exchange rates to deviate persistently from levels consistent with macroeconomic fundamentals—seems to support this conjecture. Larrain and Velasco (2002) also make a case in favor of this argument.

resolve underlying economic problems. Obviously, such problems should be addressed by more fundamental policy measures. Moreover, foreign interventions that oppose major market trends stand little chance of success; the old market wisdom, "don't stand in front of a freight train," is also valid for foreign exchange interventions.

In conclusion, the results corroborate the notion that if foreign exchange interventions are carried out with finesse and sensibly—i.e., not to defend a particular exchange rate—they could play a useful role under an IT framework in containing the adverse effects of temporary exchange rate shocks on inflation and financial stability.

Appendix
Inflation Targeting Country Central Banks
Publicly Reported Information on Foreign Exchange Market Intervention Practices, 2001

	Intervention Practices	Sources
Industrial Countries		
Australia	The Reserve Bank of Australia intervenes when the exchange rate is overshooting; and when market conditions are unsettled.	IMF Country Report 01/162
Canada	The Bank of Canada intervenes only in exceptional circumstances.	Bank of Canada Annual Report, 2000
Iceland	The Central Bank of Iceland intervenes only to adhere to inflation target or sees exchange rate fluctuations as a potential threat to financial stability.	Monetary Bulletin of the Central Bank of Iceland, November 2001
New Zealand	The Reserve Bank could intervene directly in the foreign exchange market to counteract "disorderly market conditions"; in practice the Reserve Bank has not intervened since 1985.	Reserve Bank Governor speech, October 2000
Norway	The Central Bank of Norway intervenes when the currency moves significantly out of line with reasonable fundamentals and at the same time exchange rate developments impair the prospects of achieving the inflation target. Interventions may also be necessary in the event of large short-term fluctuations of the currency when foreign exchange market liquidity is reduced.	Annual Report, 2001
Sweden	The Riksbank intervened in the currency market in June 2001, for the first time in years, to limit the impact of a sudden depreciation on inflation.	Central Bank First Deputy Governor speech, September 2001
United Kingdom	The Bank of England can intervene in the foreign exchange market.	Bank of England fact sheet on Foreign Exchange Market, Bank of England website
Emerging Market Countries		
Brazil	The Central Bank of Brazil may intervene on a regular basis, to adhere to the inflation target, or in exceptional situations.	IMF Press Release No. 01/38, Sept. 2001 and Central Bank of Brazil Annual Report, 2000
Chile	The Central Bank of Chile has the authority to intervene in exceptional circumstances; these interventions must be publicly announced and justified.	Central Bank of Chile Annual Report 2000
Colombia	The Banco de la Republica does not intervene in the exchange market to define a particular exchange rate, although auctions of foreign currency sale options are used to accumulate international reserves.	Report to the Parliament, July 2001
Czech Republic	Interventions only to moderate large fluctuations in the exchange rate.	IMF Country Report 01/112
Hungary	The National Bank of Hungary intervenes to maintain the forint in a +/- 15 percent band.	National Bank of Hungary website
Israel	The Bank of Israel has not intervened since 1997, allowing market forces to determine the appropriate level of the exchange rate within the exchange rate band. (The width of the band against a basket of currencies is 39.2 percent.)	Bank of Israel, Foreign Currency Department, 2000 Annual Report and IMF Country Report 01/133
Korea	The Bank of Korea has intervened in the foreign exchange market in recent years.	IMF Public Information Notice 01/8
Mexico	The Banco de Mexico lets the peso float freely.	IMF Country Report 01/77
Poland	A pure floating exchange rate regime has been in place since April 2000.	IMF Country Report 01/56
South Africa	The Reserve Bank did not intervene in the foreign exchange market during 2000 except to buy foreign exchange to lower the net open foreign exchange position.	IMF Public Information Notice 01/44
Thailand	Direct foreign exchange intervention is limited.	Bank of Thailand website
Turkey[a]	The Central Bank of Turkey lets the lira float freely.	IMF, Annual Report on Exchange Rate Arrangements and Restrictions (2001)

Source Carare et. al. (2002); a:Although Turkey has not adopted inflation targeting (IT) formally, official documents of the Central Bank describe the current monetary policy framework as an implicit IT.

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