Foreign Exchange Intervention in INFLATION TARGETERS in Latin America

EDITORS

Marcos Chamon, David Hofman,
Nicolás E. Magud, and Alejandro Werner

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Advance Praise

"Over the past two decades, emerging market economies throughout the world have improved their economic performance and resilience through a combination of exchange-rate flexibility and inflation targeting. Yet, strictly free-floating remains rare, and the revealed preference is sometimes to use foreign exchange intervention as an additional policy tool. When are these interventions helpful, and what practices make it more likely they will complement rather than undermine the pursuit of price stability? With a focus on Latin America, this book provides vital background to help answer these questions. It is essential reading for anyone who wants to understand how emerging economies can navigate the global financial cycle."

Maury Obstfeld
Professor of Economics at the University of California Berkley

"Emerging markets' road to development involves consolidating an open economy in terms of trade and capital flows. This requires a sound macroeconomic framework, in which a strong monetary policy anchor (such as an inflation-targeting scheme implemented by an autonomous central bank), sustainable fiscal accounts and a market-based flexible exchange rate arrangement play a key role. For this to be effective, it is critical to (i) develop a deep and liquid foreign exchange market; (ii) build an efficient regulatory framework aimed at increasing financial and corporate foreign exchange resilience (which often constrains policy alternatives); and (iii) consider foreign exchange interventions and capital flow management measures as exceptions, to be used only when distortions could compromise an adequate foreign exchange price discovery process and not to target any foreign exchange level. In this context, this book is an invaluable contribution to the analysis of experiences of Latin American countries regarding the evolution of their foreign exchange policies. Overall, the region has made progress in developing their financial markets and adopting stronger foreign exchange regimes."

Alejandro Díaz de León
Governor of the Central Bank of Mexico

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Editors' Note (August 27, 2019)

Changes were made to the PDF of this book after publication (Chapter 8, pp. 122, 128, and 135) to correct omitted callouts to a reference.

Foreword

Latin America has explored many different exchange rate arrangements over the history of the Bretton Woods period. The International Monetary System established by the 1944 Bretton Woods agreement was based on fixed but adjustable exchange rates. In those days, frequent foreign exchange intervention was simply a mechanical consequence of the choice of an exchange rate regime. Starting in the 1970s, however, advanced economies moved to more flexible exchange rates. At the same time, many developing countries sought to maintain fixed regimes to provide stability and control inflation, though not always successfully. Since the 1990s, sometimes in the aftermath of currency crises that highlighted the drawbacks of prior pegged regimes, most large Latin American economies have transitioned to inflation targeting. By construction, an inflation-targeting framework requires exchange rate flexibility. It is thus no longer clear what role—if any—foreign exchange intervention should play.

In practice, inflation-targeting central banks in emerging markets have continued to closely monitor the exchange rate, not only because of its implications for inflation, but also because of financial stability risks that sharp exchange rate movements may entail. For the most part, foreign exchange intervention has continued to be a widely used instrument in the toolkit of policymakers in these countries. Despite this widespread use, our understanding of many aspects related to this tool remains limited. In that setting, the wide variety of approaches taken by Latin American countries provides a wealth of experience for study and analysis.

Building on a comprehensive review of the evidence and practices related to foreign exchange intervention in Latin America, this new book compares country experiences and facilitates the policy discussion. Analytical chapters written by IMF staff review the main themes that emerge from the experience. Expert staff from seven key central banks in the region contributed chapters that review in more detail the goals, modalities, evolution, and outcomes of intervention policies in their respective countries.

This book documents why and how Latin American policymakers have continued to intervene in foreign exchange markets and how they have reconciled this with the primary goal of inflation targeting. Their experience is diverse, and several aspects require further research. Yet, key central themes that emerge are the importance of transparency and strong communication policies, as well as the benefits of rules-based intervention observed in the largest economies. These have arguably helped central banks in the region to strengthen the effectiveness of interventions and preserve the credibility of their monetary policy regimes. This book offers a wealth of information for central banks, including those outside the region, and for anyone else interested in learning from the Latin American experience. I hope you will find it useful.

David Lipton
First Deputy Managing Director
International Monetary Fund

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Marcos Chamon, David Hofman, Nicolás E. Magud, and Alejandro Werner
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Abbreviations

2SLS	two-stage least squares
ADF	augmented Dickey–Fuller
ALMD	Assets and Liabilities Management Division
ARA	Adequacy of Reserves Accumulation
AREAER	Annual Report on Exchange Arrangements and Exchange Restrictions
BCCR	Central Bank of Costa Rica
BCDs	Central Bank of Chile dollar-denominated bond
BCU	Banco Central del Uruguay
BIS	Bank for International Settlements
Ch	Chilean
CIP	covered interest parity
CPI	consumer price index
CSR	cost of the surplus reserves
CUE	continuously updated estimator
DIR	direct intervention
DUS	trade-weighted nominal exchange rate index for the United States
ECB	European Central Bank
EGARCH	exponential generalized autoregressive conditional heteroskedasticity
EMBI	Emerging Markets Bonds Index
FRED	Federal Reserve
FX Commission	Foreign Exchange Commission
G3	Group of Three
GARCH	generalized autoregressive conditional heteroskedasticity
GC	*gobierno central* (central government)
GDP	gross domestic product
IBR	inter-bank rate
INDIR	indirect intervention
IRFs	impulse-response functions
ITLUP	Uruguayan peso-nominated yield curve
IV	instrumental variable
LA5	Latin America 5
M1	Monetary Target
MONEX	Mercado de Monedas Extranjeras
MXN	Mexican peso
NBER	National Bureau of Economic Research
NDFs	nondeliverable forwards
NFXP	net foreign exchange purchases
NSSc	nonstatistically significant results

OECD	Organisation for Economic Co-operation and Development
OLS	ordinary least squares
PEMEX	Petróleos Mexicanos
RECOPE	Refinadora Costarricense de Petróleo
S.D.	standard deviation
S.E.	standard error
SC BCRP	Swaps Cambiarios del Banco Central de Reserva del Perú
SDRs	Special Drawing Rights
SELIC	Sistema Especial de Liquidação e Custo
SELIC	Sistema Especial de Liquidaçãoe Custo system
SR	surplus reserves
STER	sterilized
SVAR	structural vector autoregression
TES	títulos de tesorería (Treasury bills in Colombia)
TRM	*tasa de cambio representativa del mercado* (representative market exchange rate)
UIP	uncovered interest parity
USD	US dollar
UY peso	Uruguayan peso
VAR	vector autoregression
VIX	Volatility Index

CHAPTER 1

Introduction: Book in Brief

Marcos Chamon, David Hofman, Nicolás E. Magud, and Alejandro Werner

There is a growing interest in the use of foreign exchange intervention as a policy tool, particularly in emerging markets. Yet our understanding of many aspects of foreign exchange intervention remains limited, especially in countries with flexible exchange rate regimes. To contribute to the discussion, this book examines the experience of several key inflation-targeting central banks in Latin America.

Most Latin American countries have adopted floating exchange rate regimes in the past two decades, often in combination with a move to inflation targeting. Still, official intervention in foreign exchange markets has remained an important feature of policy frameworks. Many countries in the region have steadily accumulated reserves as they have leaned against sustained capital inflows, first in response to the commodity super cycle, and then as advanced economies responded to the global financial crisis with a large monetary stimulus. In some cases, countries have also deployed those reserves to counter depreciation pressures.

The modalities of such interventions, however, have varied widely. In some cases, interventions took place under a clearly laid-out framework and defined set of rules; in others, intervention was more ad hoc and discretionary. Often, intervention took place directly in spot markets and was aimed at accommodating immediate foreign exchange liquidity needs. But in some episodes, pressures in foreign exchange markets were due to hedging demand, and intervention was carried out through derivatives.

Although inflation-targeting central banks in Latin America, on average, tend to be relatively transparent about their interventions, countries' disclosure practices have differed considerably, both across countries and over time.

The Latin American experience with foreign exchange intervention is of interest because it provides insights into several key issues faced by policymakers in many emerging economies. In particular, what is—or should be—the role of interventions under a floating exchange rate regime and of inflation targeting? What are the motives for interventions under such regimes? How effective are foreign exchange interventions? Indeed, do they work at all? How should they be best conducted? And what are the costs of interventions?

To help answer these questions, this book provides the reader with an up-to-date review of foreign exchange intervention practices in Latin America and distills tentative lessons from this rich and varied experience. Building on evidence and country experience with intervention, the book aims to provide a consistent analytical framework to facilitate policy discussion.

The first part of the book covers the main thematic issues in a set of analytical chapters prepared by IMF staff. The chapters provide a broad cross-country perspective of the motives and means of intervention, by exploring the different frameworks, instruments, and operational and implementation issues. It also reviews the existing literature on the effectiveness of interventions, including a chapter that presents new evidence on the effectiveness of forward intervention. This first block of background chapters concludes with a detailed discussion of the operational challenges of foreign exchange intervention under inflation-targeting regimes.

In the second part of the book, chapters by staff of the central banks of Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, and Uruguay provide insightful narratives, as well as specific details of each country's individual experience. Topics include the developments that motivated intervention—ranging from mitigating the risks of financial dollarization (Costa Rica, Peru, and Uruguay) to managing the impact of large and sustained capital inflows and their often-sudden reversals (Brazil). Topics also include the specific modalities of interventions and their short- and medium-term effectiveness in achieving policy goals.

The chapters also describe the process with which central banks decide how and how much to intervene—in some cases presenting an illustrative intervention decision tree—and how communication around interventions takes place. One key message from the accumulated experience of inflation-targeting Latin American countries is a strong preference for transparency when intervening. Transparency can allow the market to internalize the reaction function of the central bank, helping to reduce excessive exchange rate volatility and uncertainty.

The following overview briefly summarizes each chapter.

Chapter 2 begins with a focus on intervention motives. Marcos Chamon and Nicolás E. Magud briefly review the theoretical literature on foreign exchange intervention and then explain why central banks may decide to intervene. Intervention plays a central role in fixed exchange rate regimes. However, in a floating regime (the focus of the book) the role of intervention is not clear. Yet, there are several reasons why central banks intervene. The motives for intervention include international reserve accumulation for precautionary reasons, attenuating financial stability risks from sharp exchange rate movements, managing short-term/high-frequency shocks on the exchange rate as a result of inflation pass-through concerns, and managing more persistent shocks or shocks to the real exchange rate due to competitiveness/Dutch disease considerations. The discussion focuses on the potential benefits from those channels, but the overall desirability of intervention will also depend on its cost.

In Chapter 3, Oscar A. Hendrick, Nicolás E. Magud, and Asad Qureshi present a taxonomy of foreign exchange intervention. The chapter discusses several ways in which intervention takes place in practice. Specifically, it presents different frameworks in which foreign exchange intervention can be implemented. These include whether intervention is transparently communicated to the market or conducted secretly. It also considers whether intervention is rules-based or discretionary. Beyond this taxonomy, the chapter delves deeper into the motives behind each type of foreign exchange intervention, including if intervention is done in the spot market or in the derivatives market—and the motivation behind the use of each type of intervention. Throughout the analysis, the costs and benefits of these modalities are considered.

In Chapter 4, Marcos Chamon, David Hofman, Sergi Lanau, Umang Rawat, and Miklos Vari document the evidence in the existing literature of how interventions impact exchange rates. This sheds light on why central banks are often willing to incur the costs of intervention. The chapter reviews the inherent identification challenges of assessing intervention effectiveness and the empirical strategies that have been used to tackle this problem. It reviews the evidence for the effect on the exchange rate level and on volatility, and the duration of these effects. It also reviews the evidence of the relative effectiveness of foreign exchange sales versus purchases, spots versus derivatives, and rules-based versus discretionary interventions.

Chapter 5 presents new evidence of the effectiveness of foreign exchange intervention. Chris Walker examines the effectiveness of forward intervention in foreign exchange markets, employing a simple analytical framework and presenting econometric estimates for the experience with forward intervention. Its effectiveness is assessed for the impact on spot currency markets, as well as for domestic interest rates, dollar availability in domestic markets, and capital flows. The chapter provides an analytically underpinned taxonomy of the circumstances in which forward intervention may be preferred to spot intervention or to other policy measures.

In Chapter 6, Marcos Chamon, David Hofman, Nicolás E. Magud, Umang Rawat, and Alejandro Werner explore how foreign exchange intervention is integrated under inflation targeting in Latin America. The authors discuss the challenges central banks face, including (1) tensions between foreign exchange interventions and monetary policy actions aimed at an inflation target, (2) whether the responses to appreciation or depreciation pressures have been symmetric, (3) the costs of intervention, (4) the trade-offs of transparency and communication of the monetary policy objectives, and (5) intervention under currency mismatches. They find that Latin American central banks, on balance, appear to have managed these tensions with a considerable degree of success. Clear communication policies appear crucial to conveying the primacy of the inflation objective and anchoring inflation expectations.

Turning to individual country experiences, in Chapter 7, João Barata R. B. Barroso presents the case of Brazil. The author highlights that international reserve accumulation involved "leaning against the wind," which enabled the accumulation of a large buffer of international reserves to insure against potentially destabilizing situations. Intervention also enabled the Central Bank of Brazil to offer hedging instruments at times of excess market demand. There was a significant provision of foreign exchange liquidity through repo auctions during the 2008–09 global financial crisis. Swap auctions have also been very common. Another significant episode of foreign exchange sales took place in the aftermath of the "taper tantrum" that emerged in 2013, as the US Federal Reserve announced it would eventually withdraw the monetary stimulus that had been put in place during the financial crisis. The Central Bank of Brazil intervened mostly through preannounced rules for the sale of derivatives to provide foreign exchange liquidity and to meet hedging demand. At the height of that intervention program, the outstanding volume of derivatives exceeded $100 billion. The chapter also presents a flowchart that helps explain how the central bank decides whether and how to intervene.

Catalina Larraín and Diego Saravia describe the Chilean experience in Chapter 8. Since floating its currency in 1999, Chile has intervened only four times—in 2001, 2002–03, 2008, and 2011. In the first two cases, the central bank intervened to provide foreign currency liquidity by selling US dollars and US dollar-denominated bonds. In contrast, in 2008 and 2011, preannounced programs involved regularly scheduled purchases of US dollars to reach an international reserve target. In all cases, the central bank clearly communicated the intervention programs to the public. Their results show that the announcement of an intervention program had clearer effects on the exchange rate than the actual interventions (consistent with the market pricing in the effect of the intervention in the aftermath of the announcement).

In Chapter 9, Pamela Cardozo describes foreign exchange intervention in Colombia. The Bank of the Republic intervened to accumulate international reserves to reduce external vulnerabilities, to mitigate fluctuations in the exchange rate that do not clearly reflect fundamentals and that may have adverse impact on inflation and economic activity, and to provide foreign liquidity to the market to ensure normal functioning of internal and external payments. Colombia has used options to accumulate international reserves, which are exercised when the exchange rate is below its 20-day moving average. This rule led to stronger reserve accumulation at times of appreciation pressure. Options were also used to implement analogous rules for selling foreign exchange during times of depreciation pressure. The central bank has also undertaken discretionary interventions. The chapter provides a decision tree to illustrate how the central bank decides to intervene.

In Chapter 10, Rodrigo Cubero, Valerie Lankester, and Evelyn Muñoz look at Costa Rica. This is a much more dollarized economy than others covered in this book—it only started to officially float its currency in 2015. The country is also fairly open to international trade and finance. As a result, the Central Bank of Costa Rica frequently intervenes to maintain financial stability, "lean against the wind," and avoid excessive volatility in the exchange rate. Managing the supply and demand of foreign exchange by the various public entities is also an important consideration. All interventions in Costa Rica are conducted through the spot market, because derivatives markets are not well developed. These interventions are discretionary, with no formal intervention rule communicated to the public.

Chapter 11 presents the case of Mexico. Rodrigo Cano, Daniela Gallardo, and Jaime Acosta highlight the Bank of Mexico's independence in instruments and objectives. Interest rates are only used for responding to inflation deviations from target, while foreign exchange interventions seek to mute excessive exchange rate volatility and accumulate reserves for precautionary reasons. Most interventions have taken place through preannounced programs. Reserve accumulation has been achieved through put options and following specific rules, similar to Colombia. Some rules also involved steady daily foreign exchange sales. Though less common, outright discretionary sales of US dollars have been used under extreme conditions. More recently, the Bank of Mexico has been using foreign exchange hedge auction programs (nondeliverable forward auctions) to meet market hedging needs while preserving reserves. The central bank clearly communicates intervention rules, and the markets and the public are kept informed of their implementation.

In Chapter 12, Adrian Armas and Marco Vega discuss foreign exchange intervention in Peru. The authors stress that the high degree of financial dollarization calls for active foreign exchange intervention to mitigate exchange rate volatility and potential balance sheet effects. Intervention in Peru is essentially discretionary. The Central Reserve Bank of Peru accumulates sizable reserves during tranquil times so it can comfortably deploy them if needed. Operations in the foreign exchange market are done through both spot and forward markets. Currency swaps are mostly aimed at reducing exchange rate volatility. The country's foreign exchange intervention policy appears to have been quite effective in smoothing shocks to the exchange rate, even in the case of fairly persistent shocks.

Finally, in Chapter 13, Elizabeth Bucacos, Alberto Graña, Gerardo Licandro, and Miguel Mello present the case of Uruguay. In a highly dollarized economy, the Central Bank of Uruguay intervenes frequently to reduce exchange rate volatility, which could otherwise lead to adverse balance sheet effects. Intervention also helps manage the supply and demand balance for US dollars in the domestic market, including from government entities. Uruguay is unique in its use of monetary aggregate targets instead of interest rates to achieve its inflation target.

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PART I

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CHAPTER 2

Why Intervene?

Marcos Chamon and Nicolás E. Magud

This chapter discusses some of the motives for why emerging market countries may want to intervene in the foreign exchange market, even under a flexible exchange rate regime. The motives include reserve accumulation for precautionary reasons, intervention to attenuate financial stability risks from sharp movements in the exchange rate, and efforts to manage the exchange rate due to pass-through or competitiveness concerns. The discussion focuses on the potential benefits of those channels, but the overall desirability of intervention will also depend on its cost.

INTRODUCTION

Foreign exchange intervention plays a central role in fixed exchange rate regimes. If a central bank is committed to maintaining an exchange rate, it must stand ready to buy or sell foreign exchange at that price. However, it is much less clear what role intervention should play in a flexible exchange rate regime. Standard macroeconomic models provide no guidance on the role of foreign exchange intervention. If anything, they suggest that intervention should not impact the exchange rate—that is, intervention would have no traction. Open economy models—dating back to Fleming (1962), Mundell (1963), and Dornbusch (1976)—typically assume perfect capital mobility. The uncovered interest parity (UIP) condition has become a cornerstone for such models. Under UIP, the expected change in the exchange rate is given by the interest rate differential, which in log form yields the familiar expression:

$$i_t - i_t^* = e_t - E_t[e_{t+1}], \tag{2.1}$$

where i and i^* denote the home and foreign interest rate, respectively, and e is the exchange rate (with an increase denoting an appreciation of the home currency). This condition implies that the exchange rate will respond only to changes in the interest rate differential or in the expected change in the exchange rate. No amount of sterilized foreign exchange purchases or sales by the central bank would affect the exchange rate. In practice, however, UIP does not hold. Even covered interest parity (in which futures are used in place of the expected exchange rate) has started to break down in practice (see Chapter 5). The literature emphasizes two main channels through which sterilized intervention (purchases and sales of foreign exchange

The opinions expressed in this chapter are the sole responsibility of the authors.

that leave the central bank's interest rate unchanged) can affect the exchange rate: the *portfolio balance* and the *signaling channels*.[1]

The portfolio balance channel works through the change in the relative supply of domestic and foreign currency assets (Kouri 1976). If both types of assets were perfect substitutes (that is, if UIP held), then that change in relative supply would not matter. To the extent that assets are imperfect substitutes, however, investors will demand a premium for holding more of the asset whose supply has increased, thus depreciating the currency of that asset. This portfolio balance channel may indeed have played a small quantitative role in advanced economies, where the magnitude of interventions was very small compared with their large bond markets. For example, the average coordinated intervention operation in support of the US dollar from January 1985 to December 1988 involved $278.5 million, while the average coordinated sale involved $373.2 million (Frankel and Dominguez 1993).[2] However, in many emerging markets, the stock of foreign exchange reserves is of a similar order of magnitude to the stock of domestic currency assets (Figure 2.1). The magnitudes involved suggest that the cumulative quantitative effects on asset prices through this portfolio channel could be significant, even if the channel has limited traction (see Chapters 4 and 5 for evidence on the effectiveness of foreign exchange intervention). Traction could also be higher if the emerging markets are not as well integrated into the global financial markets as their advanced counterparts (so that local and foreign currency assets become less perfect substitutes).

A few recent theoretical papers introduce frictions in otherwise standard models, which allow intervention to have traction.[3] For example, Benes and others (2015) present a model in which sterilized interventions lead to deviations from UIP through portfolio effects in a standard New Keynesian framework. Portfolio effects drive deviations from UIP in Gabaix and Maggiori (2015). Cavallino (2015) builds on that model to show how foreign exchange intervention can have sizable effects.[4]

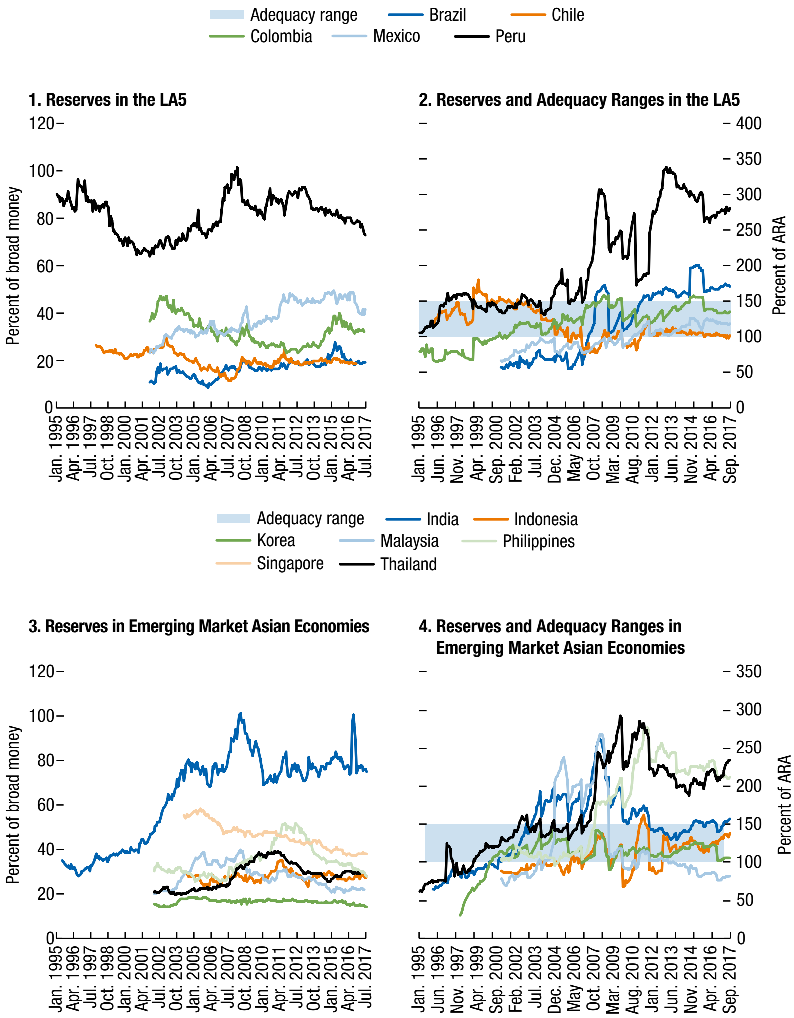
[1] Other, less explored channels exist. In the order-flow channel, the size of intervention relative to the market turnover affects price formation and the exchange rate. A related channel is the microstructure channel, which links the level of trading with that of exchange rate volatility (Frankel and Froot 1990). For sterilized interventions, Taylor (2005) suggests that the exchange rate pass-through to domestic prices decreases when the credibility of the central bank increases, reducing the need for foreign exchange intervention.

[2] One notable exception is the recent Swiss experience, where a very large stock of reserves was accumulated following the decision to place a floor on the exchange rate relative to the euro. While that policy was eventually abandoned, it showed that intervention on a massive scale is not necessarily ineffective, even in the context of a reserve currency.

[3] There are also models where the exchange rate is affected by the order flow, at least in the short- to medium-term (as discussed in Bacchetta and van Wincoop 2006).

[4] Other recent papers show a number of ways in which intervention can have an impact. For example, Garcia (2016) presents a model in which sterilized intervention causes banks to shift their portfolio from government bonds toward loans. Chang (2017) presents a model where foreign exchange intervention has traction by relaxing or tightening the financial constraints of domestic banks.

Figure 2.1. International Reserves Relative to Broad Money and IMF Adequacy of Reserves Accumulation Metric, 1995–2017



Sources: Central banks; and authors' calculations based on IMF's International Financial Statistics database.
Note: ARA = adequacy of reserves accumulation; LA5 = Brazil, Chile, Colombia, Mexico, and Peru.

Ghosh, Ostry, and Chamon (2016) present a reduced-form model that illustrates the type of frictions that can allow foreign exchange intervention to play a role. UIP implicitly assumes that capital flows would immediately move to arbitrage away any expected return differential. Suppose instead that capital flows respond to return differentials, but at a finite pace:

$$\Delta k_t = \gamma_i(i_t - i_t^* + E_t \Delta e_{t+1}) - \gamma_k k_{t-1}, \tag{2.2}$$

where k stands for capital flows and $\gamma < 1$. Thus, the standard balance of payments equilibrium condition:

$$\Delta k_t + \Delta CurrentAccount_t(Output, e_t) = \Delta Reserves_t \tag{2.3}$$

implies that both quantities (capital flows and reserves) and prices (interest rates and exchange rate) matter. That is, foreign exchange intervention impacts the exchange rate, even if interest rates remain unchanged.[5] Despite imperfect capital mobility, the foreign exchange market can always clear, provided that a sufficiently large adjustment in asset prices brings demand and supply of foreign exchange in line with each other. However, this adjustment may require very large swings in asset prices, including the exchange rate, which may be undesirable for several reasons. Central bank purchases or sales of foreign exchange assets can help narrow the magnitude of this adjustment by reducing the amount of excess supply or demand that needs to be accommodated by the private market.

The signaling or expectation channel affects the exchange rate through a change in market expectations about fundamentals (Mussa 1981). If the central bank has more information about fundamentals (including its future monetary policy stance) than the market has, it can use intervention to signal that information. And to the extent that it signals information about the future monetary policy stance, such an intervention would have traction on the exchange rate when announced, even if UIP holds (since future interest rates would impact today's exchange rate via their effect on the expected future exchange rate).[6]

The rest of this chapter discusses four main reasons that the central bank may want to intervene. As noted earlier, these include precautionary reserve accumulation, intervention to attenuate financial stability risks, intervention on concerns of pass-through to inflation, and intervention for managing more persistent shocks.

INTERNATIONAL RESERVE ACCUMULATION FOR PRECAUTIONARY REASONS

Perhaps the least controversial motive for intervening is the need to accumulate reserves for precautionary reasons. This has gained prominence especially since the 1997 Asian financial crisis. With this motive, the central bank intervenes to build up international reserves for use if adverse conditions materialize in the future, and not to affect current developments in the foreign exchange market.

Several episodes of sudden stops or reversals in private capital flows have occurred in the past, some associated with full-fledged currency and financial crises, especially in economies with fixed exchange rate regimes. Intervention

[5] In the absence of intervention, capital inflows would finance a current account deficit, or vice versa. But if the central bank intervenes and buys foreign exchange, the balance of payments, given a capital inflow, will imply a smaller current account deficit and less exchange rate appreciation.

[6] Iterating the UIP condition forward, today's spot exchange rate is determined by the sum of expected future interest rate differentials.

during such times of distress can help attenuate overshooting and other disorderly conditions that may arise in foreign exchange markets.

Furthermore, by amassing an adequate stock of reserves, the central bank can reduce the likelihood of adverse conditions materializing in the first place. For example, investors may be less likely to flee if they have confidence that the central bank can step in and help stabilize conditions in the foreign exchange market if a sudden stop takes place. Chapter 4 discusses these and other considerations when reviewing the effectiveness of intervention.

Foreign exchange reserves are among the main indicators of vulnerability that emerge from the early-warning-model literature. Most of that literature, particularly if published before the global financial crisis, focused on assessing the vulnerability to currency crises.[7] Those currency crises were typically defined either based on sufficiently large nominal and real movements in the exchange rate or on indices of currency market pressure, which typically included reserves. The early warning models were inspired by the emerging market crises of the 1990s, such as the Mexican peso crisis of 1994. Extensive reviews of that literature are provided in Kaminsky, Lizondo, and Reinhart (1998), Hawkins and Klau (2000), Abiad (2003), and Frankel and Saravelos (2012). The latter performs a meta-analysis based on those reviews and other recent studies. Foreign exchange reserves are among the most frequent statistically significant indicators in the 83 papers they reviewed.[8]

From a theoretical perspective, reserves play a central role in currency crises models. Their depletion (because of unsustainable macroeconomic policies) is at the heart of "first-generation" currency crises models (such as Krugman 1979). The level of reserves is also a key determinant of whether a bad equilibrium can exist in "second-generation" models (such as Obstfeld 1996) and its global-game variants (such as Morris and Shin 1998). And sufficiently large reserves can in principle address the vulnerabilities created by the balance sheet effects in "third-generation" models (Aghion, Bacchetta, and Banerjee 2014).

Much of this literature focuses on how reserves can prevent a currency crisis, especially when the starting point was a fixed or tightly managed exchange rate regime. However, reserves can still bring prudential benefits, even in the context of a floating exchange rate. In principle, sufficiently large movements in the exchange rate can bring supply and demand for foreign exchange in line with each other following a shock. But large movements may involve economic costs and dislocations, which make them undesirable for several reasons. By intervening in the foreign exchange market, the central bank can reduce the excess demand or supply that needs to be satisfied by the market.

[7] In contrast, Blanchard, Das, and Faruqee (2010), and Berkmen and others (2012) do not find a role for reserves when explaining the effect of the global financial crisis on emerging markets.

[8] The real exchange rate, the growth rate of credit, GDP growth, and the current-account-to-GDP balance are other important and statistically significant vulnerability indicators.

More generally, by accumulating foreign assets, the central bank can smooth the contraction in consumption following a sudden stop in capital flows. Jeanne and Rancière (2011) present a model in which policymakers choose a level of reserves to insure against a sudden stop. The optimal level of reserves depends on their cost, the probability of a sudden stop, its impact on output and consumption, and the degree of risk aversion. Their calibration found the stock of reserves to be adequate, on average, in Latin America, although they struggled to explain the continued rise in reserves over the past 10 years. Obstfeld, Shambaugh, and Taylor (2010) argue that higher reserves can be justified if they insure against domestic financial risks, including capital flight.

Low international reserves are typically a sign of vulnerability, in particular in economies with strongly managed exchange rates. However, the sharp depreciations observed in several Latin American countries after the global financial crisis led to neither high inflation nor to disruptive contractions, as they had in the past. Strong macroeconomic frameworks on the back of ample reserves likely contributed to this resilience.[9]

Even though the central bank may not necessarily be focusing on current market conditions when accumulating reserves for precautionary motives, it can still time its foreign exchange purchases in an opportunistic way. It can purchase its foreign exchange during periods when the domestic currency is appreciating. By leaning against the wind, it can moderate the pace of appreciation and make purchases when foreign exchange is perceived to be relatively "cheap."

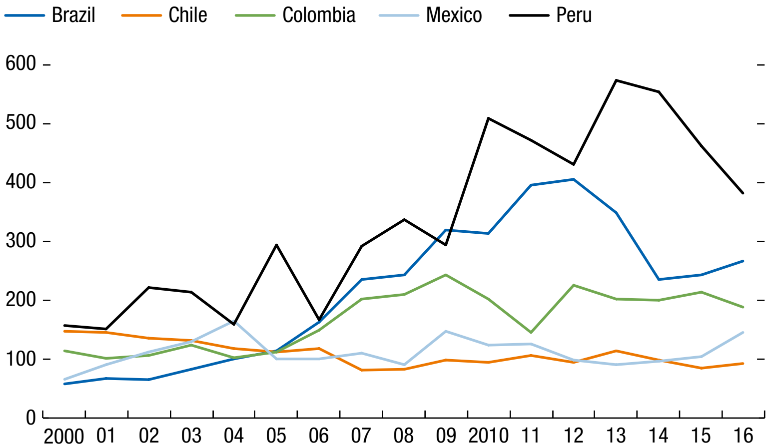
Central banks in the region have pursued this strategy, including through explicit rules. For example, when Colombia and Mexico were building up their reserves, they used options with a strike price based on the 20-day moving average of the exchange rate. That helped time their foreign exchange purchases to take place when appreciation pressures were stronger. This was also the case in Chile in 2011, when authorities announced a year-long program of international reserve accumulation to match reserve-to-GDP ratios of similar countries.

The pace of prudential reserve accumulation could pick up during episodes of capital inflows for other reasons as well. If these episodes are associated with an increase in short-term foreign exchange debt, then the pace of accumulation should increase to keep up with adequacy metrics that include that type of flow.[10] The flip side of that argument is that episodes in which short-term foreign exchange debt decrease would imply a reduction in the desired prudential level of reserves. In practice, though, countries are reluctant to deploy reserves. When prudential motives abate, they tend to adjust by halting reserve accumulation, which, over time, can bring the stock of reserves in line with reduced prudential needs.

9 For example, a large stock of reserves may assuage fears that a sharp depreciation may lead to a freely falling exchange rate (therefore, a real depreciation can be achieved with a much smaller nominal depreciation than what would have been the case in the past).

10 For a detailed discussion of reserve adequacy, see IMF 2015.

Figure 2.2. International Reserves to Short-Term Debt, LA5 Countries, 2000–16
(Percent)



Sources: Central banks; and authors' calculations based on IMF's International Financial Statistics database.
Note: LA5 = Brazil, Chile, Colombia, Mexico, and Peru.

The level of international reserves appears to be adequate in Latin America. Using either the IMF's adequacy of reserves accumulation (Figure 2.1) or the ratio of international reserves to short-term debt (the so-called "Guidotti-Greenspan rule"), in all cases the level of international reserves for the Latin America 5 (LA5) countries seems appropriate (Figure 2.2). In the case of Peru, however, the stock of reserves seems large by both metrics.[11]

A number of challenges are involved in assessing whether reserves are excessive. To begin with, the probability of a sudden stop may be a function of the level of reserves; for example, investors that would otherwise "rush to the exits" in an adverse shock may decide to keep their positions if they feel the central bank has enough reserves to smooth that shock. This seems to be an empirically relevant channel, as shown by the predictive power of reserves in the early warning literature, as discussed earlier. Alternatively, the presence of reserves may encourage risky liability structures; for example, borrowers taking on short-term external debt because they can count on the central bank to provide foreign exchange liquidity if they were to face tighter global financial conditions (Kim 2008).

More generally, much of the benefit of reserves stems from the option of deploying them in the event of distress (rather than from their actual deployment). In game theoretical terms, their use "off the equilibrium path" can bring many benefits, even

[11] Peru's economy is highly dollarized, which creates additional precautionary motives for holding reserves that are not captured by that metric (such as the need to provide foreign exchange liquidity as a lender of last resort).

if reserves are not deployed. The majority of countries in Latin America have not experienced a major homegrown crisis since the early 2000s. The decline in currency mismatches, and the large stock of reserves accumulated, certainly played a significant role in building that resilience. However, even if the prudential benefits of reserves are very large, they are likely subject to diminishing returns. For example, in a standard buffer–stock savings model, an additional dollar buys less and less in terms of consumption insurance at the margin. Similarly, the prudential benefits of accumulating reserves past an adequacy level are likely to decline at the margin (whereas the moral hazard effects on private sector risk-taking behavior may not).

INTERVENTION TO ATTENUATE FINANCIAL STABILITY RISKS

Advanced economies with floating exchange rate regimes often have a "benign neglect" view of the exchange rate. This is supported by a long history of exchange rate swings, sometimes sizable, without adverse effects for financial stability.

Among emerging market central banks, however, financial stability concerns feature much more prominently. They typically dislike sharp movements in the exchange rate, particularly those that involve a sharp depreciation. Currency mismatches on corporate and financial balance sheets are a major source of financial fragility. They played a central role in currency crises in the region, including high profile cases such as Mexico in 1994, Brazil in 1999, and Argentina in 2001. When currency mismatches are present, sharp movements in the exchange rate can easily render a borrower insolvent—including the government. And if mismatches are present in the financial sector, the shock can easily gain a systemic dimension. These mismatches have declined over time, due to tighter financial supervision and regulation, and a greater awareness of the risks involved among borrowers. But there is a genuine fear that pockets of vulnerability may emerge during times of distress. For example, large firms suffered heavy losses in Brazil and Mexico because they used complex foreign exchange derivative products.

In principle, a depreciation that is not warranted by perceived fundamentals could be self-correcting, to the extent that the overshooting of the exchange rate increases the expected returns in local currency. That should entice investors to keep, or even increase, their local market exposures. However, in practice, it is feared that sharp depreciations can create adverse dynamics in the foreign exchange market, beyond what is warranted by fundamentals. The exchange rate's automatic stabilizer role may thus break down, resulting in disorderly conditions, as discussed in IMF (2015). Several factors can contribute to adverse dynamics in the foreign exchange market, including the fears of unknown currency mismatches (that is, even if mismatches are small, investors may still flee because they believe, or expect that other investors believe, that mismatches are potentially serious).

The case for intervention under those circumstances is fairly uncontroversial, unless the extent of intervention is perceived to be excessive; that is, if the central bank is perceived to be resisting the movement to a new equilibrium.[12] We should bear in mind that it is very difficult to assess the equilibrium exchange rate in real time, and whether movements, even if sharp, should be considered "excessive." In the limiting case, excessive intervention could become unproductive if it facilitates capital flight that would not otherwise take place under a more depreciated exchange rate. In general, there can still be a case for some intervention to help smooth the impact of a permanent shock if that helps prevent financial stability risks from materializing. However, the central bank should remain mindful of the moral hazard that this can create (such as encouraging excessive risk-taking behavior by the private sector because of an implicit "put").

Conversely, central banks may also intervene to slow the pace of appreciation if they fear that it is moving the exchange rate away from fundamentals and setting the stage for an eventual correction that could be disruptive. This type of intervention is discussed in more detail later in the chapter.

INFLATION PASS-THROUGH

Another motive for intervening is the concern of pass-through to inflation. Exchange rate pass-through has declined over time, as central banks in the region have established their credibility—and despite marked increases in import ratios (see Carriere-Swallow and others 2016). However, the sheer size of a sharp depreciation can still have nonnegligible effects on inflation, even under a small rate of pass-through. Moreover, there may be concerns that the effects may be nonlinear, and become stronger after a large depreciation, with some threshold level of depreciation after which the pass-through increases.

Also, the exchange rate remains an important focal point people use to assess the strength of the economy. A large depreciation may adversely affect confidence and price- or wage-setting behavior, even in the nontradable sector. If the shock to the exchange rate is permanent or highly persistent, the economy will need to cope with and adjust to it. If a large swing in the exchange rate is perceived to be temporary, then there could be a case for using foreign exchange intervention to counter that overshooting and to limit its impact on inflation, inflation expectations, and relative prices more generally—which could in fact affect resource allocation.

This motive for intervention is less controversial, to the extent that it is consistent with the monetary policy objective (meeting the inflation target) and is driven by the response to a perceived temporary shock to foreign exchange markets. The case for using intervention is stronger if it has a more immediate effect on the exchange rate and avoids the need to adjust the policy rate in response to

12 There have been large episodes of reserve deployment in the region, including Brazil's foreign exchange swap program, which at its peak corresponded to about one-third of reserves (about $100 billion). Moreover, the settlement of these operations was in domestic currency. However, episodes of sustained deployment remain rare compared to episodes of sustained accumulation.

exchange rate developments (central banks typically want to adjust the policy rate gradually and predictably, making it a less suitable instrument to respond to high-frequency fluctuations). However, inflation-targeting countries need to credibly highlight that foreign exchange intervention is subordinated to interest rate policy to avoid misperceptions and potential confusion about the central bank's objective (which, if not well articulated, could be a significant cost of intervention).

MANAGING MORE PERSISTENT SHOCKS

Typically, sustained intervention is associated with capital inflows, since the fear of running out of reserves (or seeing them drop below prudential metrics) eventually limits the willingness to sell foreign exchange. However, the question of how to respond to persistent depreciation pressures will likely become more and more pertinent if the global financial cycle reverses, and countries experience sustained capital outflows. This is somewhat uncharted territory, and the discussion is left for Chapter 6.

One of the main concerns in the face of persistent capital inflows is the loss of external competitiveness and Dutch disease considerations. These concerns tend to be labeled as mercantilist. It should be acknowledged, however, that it can be quite costly for an economy to adjust rapidly to the new equilibrium exchange rate, and for workers to move from the tradable to the nontradable sector and back, following a persistent appreciation that eventually reverses. Tradable firms may be credit constrained, go out of business, and only slowly be replaced by new entrants once the cycle reverses. The presence of currency mismatches in nontradable sector firms will only compound such a problem.

Sustained capital flows can also exacerbate prudential concerns. While the risks of capital flows are typically associated with "hot money" flows that can quickly reverse, persistent inflows can fuel credit and asset price booms, which often result in crises. These are of concern for countries with shallow financial markets. Persistent flows may be even riskier, since the longer the climb, the larger the potential fall. Risks can be amplified if the domestic financial system does not allocate the easy money toward productive uses, and instead uses it to finance consumption booms or asset price bubbles.

Despite these legitimate concerns, it is not clear whether intervention is an adequate tool to manage persistent shocks, for several reasons. First, it becomes harder to make the case that intervention is used to prevent an overshooting of the exchange rate, as opposed to resisting the movement to a new equilibrium. There are also concerns that intervention may become less effective over time. By smoothing the shock to the exchange rate, the central bank may encourage more inflows during the boom phase (as investors expect the exchange rate to continue to appreciate, which increases their expected gains). The opposite is also true, and intervention may stimulate outflows when the capital flow cycle turns (as investors want to take advantage of the delayed adjustment to flee at a more favorable exchange rate). To the extent that intervention is perceived to be costly, it may become a less suitable tool for dealing with permanent shocks, even in models where it continues to have traction (Ghosh, Ostry, and Chamon 2016). In these circumstances, there is a stronger case for adjusting the macro policy stance in response to the shock. Intervention may play a supporting role, at best. A full-fledged discussion of how to manage capital flows is beyond the scope of this chapter, which focuses only on intervention. For that discussion, please refer to IMF (2012).

CONCLUSION

This chapter discusses motives for foreign exchange intervention under a flexible exchange rate regime.[13] It emphasizes that even if intervention seems desirable, its cost must also be considered, and the exact nature of those costs remains a subject of debate.

Many point to the interest rate differential as a measure of the cost of holding reserves. Yet that does not give a complete picture, as it fails to consider the change in the exchange rate, which can make intervention even more costly due to the forward premium puzzle (in which the higher interest domestic currency would tend to appreciate). Likewise, to the extent that the central bank leans against the wind, and intervenes when the exchange rate overshoots, the resulting valuation effect may reduce the costs. Furthermore, the interest rate differential fails to factor in differences in credit risk. Perhaps more important, it abstracts from the fact that international reserves can reduce risk premiums, not only for sovereign borrowers, but also for corporate and financial borrowers.[14]

Although settling this debate is beyond the scope of this book, it seems reasonable to assume that these costs are not minimal. Authorities would therefore typically need to make a compelling case for the benefits of intervention.

The policy framework and the policy mix can also influence the adoption of alternative countercyclical policies, including foreign exchange intervention. For example, an economy that is well integrated with global financial markets and is experiencing overheating may fear that raising interest rates to cool domestic demand could stimulate larger capital inflows. These inflows can fuel domestic credit expansions and stimulate demand. They can also contribute to asset price inflation—or even unsustainable asset price bubbles—and inflationary pressures. This would result in appreciation pressures, which could drive the policymaker to consider foreign exchange intervention, along with macroprudential policies—or even capital controls as a more frequent instrument among the usual elements in the policymaker's toolkit. Chapter 6 revisits these issues.

[13] The actual effectiveness of intervention is left for Chapter 5, whereas Chapter 4 presents existing evidence.

[14] For a detailed discussion of alternative metrics of this cost, please refer to IMF (2015).

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CHAPTER 3

A Taxonomy of Intervention

Oscar A. Hendrick, Nicolás E. Magud, and Asad Qureshi

This chapter presents different frameworks for implementing foreign exchange interventions, including whether they are transparently communicated to the market or kept secret, and whether they are rules-based or discretionary. The chapter also delves into the motives for the various types of foreign exchange intervention, including whether interventions take place in the spot market or in the derivatives market—and the rationales for each type. The chapter also summarizes recent interventions in some Latin American countries.

OBJECTIVES AND TRANSPARENCY

The issue of transparency in foreign exchange intervention has been the subject of much debate among policymakers and economists. A review of the literature shows that secret intervention by central banks has been supported by several authors. For instance, Vitale (1999) argued that secret sterilized intervention can be used to influence agents' expectations and exchange rates, given the access to private information on these fundamentals. Sarno and Taylor (2001) found evidence of the effectiveness of secret official intervention, through either the portfolio channel or the signaling channel. They also argued that coordination among central bankers, and some degree of transparency may enhance the foreign exchange intervention. The empirical work undertaken by Dominguez and Frankel (1993), with the use of data on intervention and exchange rate expectations, was instrumental to overcome two major handicaps characterizing the empirical studies of the 1980s, which largely rejected the effectiveness of intervention. Based on the comprehensive IMF's 2001 Survey of Foreign Exchange Market Organization, Canales-Kriljenko (2003) found that on some occasions the central bank would benefit from keeping its foreign exchange intervention secret. In these cases, the informational advantage to the central bank may protect it to some degree from speculative attacks and falling into speculative trading games from large traders in the market. On the other hand, in the context of a meeting of deputy governors of central banks from major emerging market economies to discuss foreign exchange intervention, Archer (2005) found that many policymakers are more in favor of transparency regarding the intervention ex ante, and transparency about actual intervention operations ex post. However, secret

The opinions expressed in this chapter are the sole responsibility of the authors.

interventions were still supported by some, under the rationale that the market has no target to attack, or to avoid the perception that the central bank has failed. More recently, central banks with full-fledged inflation-targeting frameworks and with strong credibility rely more on transparency ex ante and ex post regarding the frequency and amount of intervention.

Yet, even when transparency is chosen, several issues surround its degree and type. It is important to distinguish between policy transparency and operational transparency. In the first case, central banks can decide to disclose the rules of foreign exchange intervention on a general level (such as smoothing out excess volatility), or on a specific level (such as the triggers for intervention and how they work). Regardless of the level of transparency, some central banks prefer not to disclose trading tactics, because, in some cases, those tactics can give some market participants an undue advantage to bet against the central bank and undermine the objectives of the foreign exchange intervention.[1]

It can be argued that "tactical ambiguity" about the exact timing and amount of intervention will heighten prospects for achieving the intervention objective efficiently, that is, with the least amount of intervention. Transparency can be in "real time," when the central bank explains its actions as they happen, ex ante (before they happen), or ex post (after they happen) (Enoch 1998).

A central bank's credibility is also relevant when deciding the level of transparency. On the one hand, some experts suggest that if a central bank is credible, and market participants understand its underlying rationale for intervention, transparency could be reduced. On the other hand, a central bank with strong credibility may want to reveal its actions so that the market can benefit from the central bank's signaling effect.

Transparency policy (or the degree of its transparency) may also vary with the specific objectives of intervention, the tools available to the central bank, the number of players in the foreign exchange market, and the depth and liquidity of money and capital markets in the country. In some cases, market participants may speculate against a central bank in which operations are bound by excessively strict rules. Ex post transparency could also be effective if the central bank's signaling, after the intervention, influences market expectations by transmitting information on the fundamentals or on future policy actions.

Transparency is also related to the motives of intervention (see Chapter 2). As argued in previous chapters, spot interventions help address liquidity imbalances in the foreign exchange market: buying if there is excessive foreign exchange in the market (such as owing to capital inflows) or selling if there are sudden capital

[1] Bank for International Settlements Working Paper 144/2003: "Transparency versus Constructive Ambiguity in Foreign Exchange Interventions" refers to the IMF Code of Good Practices' case for enhancing central banks' intervention transparency. However, it also highlights that the code states that " . . . there are circumstances where full transparency may not be beneficial to achieve policy goals, . . . the Code recognizes that there may be justifications for limiting certain disclosure practices in situations where increased transparency could endanger the effectiveness of policies, or be potentially harmful to market stability."

outflows or seasonal liquidity shortages of foreign exchange. Against a foreign exchange hedging demand, swap interventions could be more useful for easing the hedging needs of participants and avoiding excessive and unnecessary pressure on the spot market. This point is subsequently elaborated.

The transparency of intervention practices varies across countries. For example, Group of Three (G3) countries began enhancing intervention transparency in the mid-1990s. The Federal Reserve started to report its intervention activity on its webpage quarterly, and it released daily intervention figures with a one-year lag. Hung (1997) estimates that about 40 percent of the Federal Reserve's foreign exchange interventions during 1985–89 were not announced. The Bank of Japan did not announce its interventions either, but it reported the amounts of exchange rates ex post. The European Central Bank (ECB) announced some of its interventions, although the information contained in the announcements was limited and did not include amounts and timing (Canales-Kriljenko, Karacadag, and Guimarães 2003). In emerging markets, according to a survey on intervention practices in 90 countries, about half of the central banks in these economies announce their presence in the market, while the evidence on how much central bank practices are secret is mixed (Canales-Kriljenko 2003).

In Latin America, some countries have had episodes of secret ex ante foreign exchange interventions in the past, although in most cases, the intervention was made public ex post and its rationale explained. Recently, a move to more transparency and more to rules than discretion, has been observed, in tandem with central banks' shift from monetary aggregate anchors to full-fledged inflation-targeting frameworks. Also, the degree of intervention has been reduced or eliminated altogether in some countries. Yet, during the global financial crisis of 2008–09, some monetary authorities reinstated foreign exchange intervention as a temporary recourse, either to rebuild the level of international reserves, as in Chile in 2011, or to smooth out volatility, like Colombia did in 2012. Some countries, such as Peru, have continued to use discretion over rules (see Chapter 12).

Debate is ongoing about the costs and benefits of either strategy, but empirical observation, as illustrated in the country chapters, makes it clear that there is no one rule that fits all. Yet, a case can be made that transparency may be the best approach to foreign exchange intervention, as Chapter 6 discusses.

A few central banks disclose or publish data pertaining to foreign exchange interventions. Some provide initial guidance close to intervention time, while others publish the data with a lag. Rare interveners, such as the Bank of Canada or the Bank of England, disclose volumes close to the intervention time; others prefer to publish intervention volumes with a lag spanning one to six months. For example, Japan discloses daily volumes with a six-month lag, while Australia discloses monthly volumes with a one-month lag. Brazil used to publish intervention data with a one-week lag but now prefers to release market operations data through monthly press releases on its website. The Hong Kong Special Administrative Region and Paraguay publish foreign exchange intervention volumes the same day. In general, most central banks in Asia and Africa do not publicly disclose intervention data. Table 3.1, from the IMF's Annual Report on

Exchange Arrangements and Exchange Restrictions, reveals several central banks' disclosure practices.

It is important to note that a central bank's credibility in its commitment to the inflation target is crucial for all inflation-targeting countries. Clear rules of engagement for foreign exchange intervention, and clear messages that the main objective is the inflation target, and not a specific exchange rate level, are instrumental for building and maintaining a central bank's reputation.

RULES VERSUS DISCRETION

Regardless of how transparent it is, foreign exchange intervention can be rules-based or discretionary. In some cases, monetary authorities clearly establish the conditions for an intervention to take place. Some rules are specific and state the amount or the nature of the purchases or sales of foreign currency. Some even clarify the objectives for such interventions. Those objectives could include mitigating exchange rate volatility to rein in financial stability, alleviating hedging needs for exporters, or supplying cash for those needing to fulfill external debt obligations or for imports. It can also be related to competitiveness in a growth-led strategy. In other cases, the central bank follows no rules. When perceptions of problems in the foreign exchange market arise—including financial stability, exchange rate level, liquidity issues, or others—the central bank decides to arbitrarily intervene. That decision is an example of discretionary foreign exchange intervention. Discretionary interventions are not only ad hoc about what triggers the operation but also about the amount of sales and purchases, and the modalities of the sales and purchases. By definition, discretionary foreign exchange interventions are much less predictable than rules-based interventions.

Beyond preestablished policy response functions based on specific rules, central banks can announce programs of purchases or sales of foreign currency. For example, central banks can aim for certain levels of international reserves as a share of GDP, of imports, or of short-term debt obligations. Typically, the goal is to be on par with countries of similar characteristics. The goal could also be to preempt exchange rate levels perceived as persistently deviating from fundamental values as a way to minimize resource misallocations that could be detrimental to economic activity.

Regardless of the ultimate objective, central banks preannounce programs for purchasing or selling foreign exchange for a preestablished period. Typically, the program also specifies regularly timed auctions of foreign exchange as well as the volume in each auction (often at a constant rate). This mechanism allows the central bank to predictably convey the message to the market of an intervention to limit any disruption. It may also implicitly point to the expected path of monetary policy that is consistent with the foreign exchange intervention in some cases (Mussa 1981)—thus also revealing the central bank's projections to the market and, thereby, its price stability. In Latin America recently, Chile aimed to build reserves and mitigate the effect of a persistent appreciation in 2011, and

TABLE 3.1.

Current Disclosure Practice: AREAER Survey Results 2016

Economy or Region	Immediate Disclosure and Other Disclosure Channels and Time Lags
Armenia	The Central Bank of Armenia publishes intervention data on its website weekly on Mondays.
Australia	Monthly purchases and sales of foreign exchange are published on the Reserve Bank of Australia website with a one-month lag. Daily data on foreign exchange market interventions are published on the website annually, with the release of the central bank's annual report.
Azerbaijan	The Central Bank of Azerbaijan publishes foreign exchange intervention data quarterly.
Bolivia	The Central Bank of Bolivia publishes exchange market intervention and foreign exchange purchases and sales data in "Weekly Statistics" on its website.
Brazil	The Central Bank of Brazil publishes intervention data monthly on its website on currency flows and open market operations.
Canada	Interventions are announced on the Bank of Canada's website, and the amount of intervention is published in the government's monthly official press release on international reserves.
Chile	The Central Bank of Chile usually announces the amount of foreign exchange it intends to buy or sell in its monthly bulletin. It publishes auction results daily and reserves weekly.
Colombia	The central bank of Colombia, the Banco de la República, publishes daily and monthly intervention results in the foreign exchange market and information regarding each auction on its website.
European Union	The European Central Bank publishes information on interventions. When it intervenes, the ECB intervenes at the market prices' quotes.
Guatemala	The Bank of Guatemala, effective November 2012, publishes the foreign exchange intervention data on its website.
Hong Kong SAR	The Hong Kong Monetary Authority makes immediate announcements of the impact on the aggregate balance from purchases or sales of US dollars through various information outlets, including Reuters and Bloomberg Finance L.P., and on its website.
Iceland	The Central Bank of Iceland publishes monthly data on foreign exchange interventions in the foreign exchange market.
India	The Reserve Bank of India publishes monthly data on its interventions (foreign exchange purchases and sales) in its monthly bulletin, with a six-week lag.
Indonesia	Bank Indonesia does not disclose data on its interventions.
Jamaica	The Bank of Jamaica publishes information on its interventions in its Annual Report and Quarterly Monetary Policy Report.
Japan	Interventions in Japan fall within the mandate of the ministry of finance, which publishes daily purchases and sales amounts as well as intervention currencies on its website with a lag.
Korea	Korean interventions in the spot market or through derivatives in the forward market are not announced, and intervention data are not published; there are no regular channels. Figures on foreign exchange reserves are published twice a month, but their movements are affected by several factors, in addition to foreign exchange interventions.

(continued)

TABLE 3.1. ***(continued)***

Current Disclosure Practice: AREAER Survey Results 2016	
Economy or Region	**Immediate Disclosure and Other Disclosure Channels and Time Lags**
Mexico	The Bank of Mexico publishes results of all foreign exchange interventions on its website, including the new foreign exchange hedging program of nondeliverable forwards announced by the Foreign Exchange Commission on February 21, 2017. All results of past rules-based and regular auctions are also publicly available.
Peru	The Central Reserve Bank of Peru publishes daily information about its intervention operations on its website.
Russian Federation	The Bank of Russia publishes information about the frequency and volume of foreign currency interventions on its website under the "Liquidity of the banking sector and monetary policy instruments" subsection of the "Statistics" section.
Singapore	The Monetary Authority of Singapore intervenes through agents and does not publish information on its interventions.
Sweden	Sveriges Riksbank announces each intervention in a press communiqué, explains the motive, and discloses the framework of intervention and amount data.
Turkey	The Central Bank of the Republic of Turkey publishes results of auctions and the volume of its direct interventions on its website with a lag.
Uganda	The Bank of Uganda publishes information on interventions in its monthly, quarterly, and annual reports, including breakdowns for reserve buildup, interventions, and targeted transactions.
United Kingdom	The Bank of England has a separate pool of foreign exchange reserves, which it uses at its discretion to intervene in support of its monetary policy objectives. A monthly press release issued by Her Majesty's Treasury reports the treasury and central bank interventions.
United States	The Federal Reserve Bank of New York acts as the operating arm of the Federal Reserve System. Interventions are announced when they occur, and the size of the interventions is reported in the Federal Reserve Foreign Exchange Operations quarterly bulletin.

Source: IMF AREAER 2016.

Mexico implemented a program for purchasing foreign exchange in 2017 to counterbalance the instability arising out of the North American Free Trade Agreement renegotiations.

In theory, the discussion between rules and discretion for monetary policy is well established. Going back as early as Kydland and Prescott (1977) and Barro and Gordon (1983), monetary policy debates have focused on problems of time inconsistency. In that literature, when discretionarily choosing monetary policy to achieve an inflation target jointly with an output gap target, the welfare-optimizing equilibrium results in an inflation bias, owing to a conflict of interest (Drazen 2003). In Calvo (1978), the central bank faces the problem that the optimal inflation target today may not be the optimal target come next period for maximizing some fiscal objective. Agents internalize this. Yet, the outcome is not first best. The central bank can then have rules that solve the maximization problem and thus avoid the cost of discretionary policy. However, rules also involve economic costs. The trade-offs related to each of the mentioned costs result in the optimality of rules or discretion. Rogoff (1985) extends this literature, showing that having a more hawkish central banker reduces the costs associated with the time-inconsistency problem.

For foreign exchange intervention, the same logic need not necessarily apply. Rather, rules give the authorities predictability instead of tying the central bank's hands. Presumably, such predictability would reduce financial instability. For example, Montoro and Ortiz (2016) show that in a general equilibrium model, the amount of foreign exchange intervention needed to stabilize the exchange rate under rules is much smaller than under discretion. However, rules also limit the ability to respond differently when needed; in some circumstances, discretion to intervene in foreign exchange markets could be more effective precisely because of its lack of predictability. Not surprisingly, then, it is observed that in Latin America and in many other regions, central banks sometimes prefer rules-based foreign exchange intervention, but many other times they choose to stick to discretionary policies for foreign exchange intervention.

Moreover, for inflation-targeting countries, foreign exchange intervention needs to be clearly subordinated to the inflation target, the main objective of the central bank. Otherwise, it could trigger another variety of the time-consistency problem raised earlier; for example, if the central bank is perceived to pursue an exchange rate objective rather than an inflation target objective. For inflation-targeting central banks, then, it is key that the market understands that regardless of whether foreign exchange intervention aims at mitigating the exchange rate pass-through to domestic prices of rapid and large changes in the exchange rate or at reducing the effects of financial stability resulting from excessive exchange rate volatility, the ultimate goal of intervention is to keep inflation in check. The connection between foreign exchange intervention and the inflation target need not be direct, however. An indirect channel would be financial stability concerns resulting from currency mismatches that could lead to higher inflation if they triggered financial instability. In any case, foreign exchange intervention should always be subordinated to achieving the inflation target.

The central bank can announce the general rules of intervention without specifically indicating limits on the amounts and frequency of interventions (see the earlier discussion on transparency of intervention). Rules of intervention could be very specific; yet they must be designed to preclude the main players in the foreign exchange market from taking unfair advantage of their position in the market. In general, inflation-targeting central banks would be better served by announcing the rules of engagement for foreign exchange intervention. These rules could be specific or more qualitative, such as leaning against the wind or reducing excess exchange rate volatility to limit the negative effects of large exchange rate fluctuations not supported by changes in the fundamentals.

Connected to these rules, and the transparency of interventions raised in the first section, are interventions related to paragovernmental institutions. For example, in Mexico, the cash flows of the state-run oil company PEMEX demand and supply substantial amounts of US dollars each year because of the company's crude oil exports and gasoline and other petroleum-related imports. Low-capacity utilization resulted in a negative balance contribution to international reserve accumulation in the first half of 2017. By law, PEMEX must sell to the central bank all foreign exchange that results from exporting crude oil. However, when the proceeds from crude exports are not enough, or when foreign debt payments are due, PEMEX buys US dollars from the central bank. Given the size of PEMEX—which until 2017 had been the largest contributor to international reserve accumulation—its purchases and sales of foreign currency need to be properly coordinated with the central bank. In the past, especially before the 1990s, it was common for Latin American state-owned firms to borrow abroad. Lack of coordinated sales and purchases of these government agencies worked in practice as very volatile and unpredictable foreign exchange interventions and increased financial instability. In Chile, the state-owned copper company Codelco distributes part of its sales to the government. Whether that foreign exchange ends up in the government's account in the central bank or a commercial bank (in particular, the state-owned bank *Banco Estado*), is not clear. Notwithstanding that, Codelco also purchases and sells foreign exchange in the market—including foreign exchange hedging—thus affecting market exchange rates.

The frequency of exchange rate interventions depends partly on the nature of the interventions. Preannounced programs are the most predictable, not only in volume, but also in frequency. Rules-based intervention can be anticipated by the market. Although frequency cannot be perfectly estimated, market conditions on the back of a transparent rule enable the anticipation of when thresholds could trigger an intervention. Anticipating discretionary intervention is, by definition, more difficult. Thus, its frequency is less homogenous over time.

In Latin America, foreign exchange intervention has been varied. Different countries have resorted to rules and discretion. Moreover, several countries have switched from rules to discretion and back over time. For example, as mentioned earlier, Chile intervened in 2011 with a preannounced program to purchase international reserves to match similar countries' reserves-to-GDP ratios (see Chapter 8). Colombia and Mexico have, at times, used rules that specified that when the daily volatility of the exchange rate over a specific number of days' moving average exceeded a preestablished threshold (20 days), intervention was triggered. Colombia discontinued this rule in May 2016 (Chapter 9). Mexico stopped that program in February 2016 (Chapter 11).

At other times, intervention in Colombia and Mexico has been more ad hoc, that is, discretionary. Brazil also implemented rules-based interventions for some time in response to the so-called 2013 taper tantrum (Chapter 7). This involved daily auctions of $3 billion per week from August 2013 focused on preannounced swap and repo operations. The program was originally scheduled to stop at the end of 2013, but it was extended several times, before ending in March 2015. More recently, Mexico introduced a program of up to $20 billion of nondeliverable forwards (NDFs) settled in pesos in late February 2017; and $1 billion short-dollar contracts were auctioned in March 2017. In October of the same year, this program increased to $5 billion. The additional $4 billion was allocated as follows: $1 billion the day after the announcement (October 25, 2017), with maturities of one month ($400 million), two months ($300 million), and three

TABLE 3.2.

Importance of Various Motives for Intervention, 2005–06 and 2011–12

	Importance in 2005–06			Importance in 2011–12		
Motive	**High**	**Moderate**	**Low**	**High**	**Moderate**	**Low**
To curb excessive exchange market speculation	8	4	0	11	4	0
To maintain monetary stability	7	2	2	10	2	2
To discourage sharp capital inflows or outflows	4	3	1	5	5	1
To build or reduce foreign exchange reserves	7	0	2	6	2	2
To smooth the impact of commodity price fluctuations	3	1	3	4	1	3
To maintain or enhance competitiveness	2	2	3	4	1	3
To alleviate foreign exchange funding shortages of banks and corporations	4	2	0	5	2	0

Source: Bank for International Settlements Questionnaire, February 2013.
Note: The data show the number of central banks, out of 19 that were surveyed, that responded to the importance of various motives, rating on a scale of 1 (most important) to 7 (least important); "high" indicates a response of 1 or 2; "moderate" indicates a response of 3 through 5, and "low" indicates a response of 6 or 7.

months ($300 million), followed by weekly auctions of $500 million every Wednesday until early December 2017.

IN WHICH MARKET—SPOT OR DERIVATIVES?

As Chapter 2 notes, foreign exchange intervention typically has several objectives, which may include price stability, financial stability, buffer building, and in a few instances, market development. To achieve these objectives, authorities consider foreign exchange intervention complementary to interest rate policy to contain inflationary pressures from exchange rate pass-through and preserve financial stability by mitigating risks from currency mismatches. It therefore supports economic growth in episodes of financial instability, at least indirectly. Accumulating international reserves to build stronger buffers that can respond to external shocks is typically also referred to as a motive for intervention.

Several factors drive a central bank's decision to intervene to achieve its intended objectives. These then lead to the modalities and instruments used to achieve the desired results. Inflation-targeting central banks in Latin America predominantly use foreign exchange intervention to smooth out excessive exchange rate volatility and to create strong external buffers against unexpected shocks by accumulating a high level of international reserves. Regardless of the motives within the region, a key question is which market and instruments are most effective in attaining the objectives. Table 3.2 lists some key motives.

TABLE 3.3.

Widely Used Foreign Exchange Intervention Instruments

Instrument	Mechanism of Central Bank
Foreign exchange spot transactions	Buys and sells foreign exchange spot
Foreign exchange forwards	Buys and sells foreign exchange at an agreed rate and date in the future
Foreign exchange swaps or repos	Buys and sells foreign exchange spot and purchases foreign exchange forwards on a predetermined date
Forwards, nondeliverable forwards, futures	Pays domestic currency equivalent of change in foreign exchange value on a predetermined date
Foreign exchange options	Sells option to buy foreign exchange if the currency exceeds threshold

Source: IMF staff.

TABLE 3.4.

Foreign Exchange Instruments of the Latin American Central Banks

	Modality of Foreign Exchange Instruments				
Instrument	Bilateral	Auction	Window[2]	Tenors	Other Characteristics
Foreign exchange spot	✓	✓		Today/tomorrow / spot	Discretion/rules-based
Foreign exchange forwards/ nondeliverable forwards	✓	✓	✓	Standard tenors	Discretion/rules-based Exchange traded
Foreign exchange swaps[1]	✓	✓	✓	Standard tenors	Bilateral/discretionary Auctions/rules-based Window/rules-based
Foreign exchange repos		✓		Standard tenors	Irregular/discretionary
Foreign exchange options		✓	✓	Mostly in one month	Discretion/rules-based
Others			✓		Discretion/rules-based

Source: IMF staff.
[1]Usage includes for hedging with underlying exposure.
[2]Window operations include exchange-traded instruments.

This section aims to present a taxonomy of intervention practices in Latin America. Specifically, it highlights practices typically used by countries in the region that are conditional on the type of shock they are trying to mitigate.

Sterilized intervention in spot markets is one instrument at central banks' disposal. It remains the market choice, but by no means the only one. Latin American central banks use a diverse range of instruments to intervene in the foreign exchange market. These include forwards, swaps, repos, NDFs and options, as well as US dollar–linked debt. Most central banks in the region have used both spot and derivatives markets extensively. Table 3.3 presents some of these instruments, as well as the mechanism through which each operates.

The rationales that central banks give for experimenting with a wide variety of instruments besides the spot market include the structure and growing

TABLE 3.5.

Foreign Exchange Intervention Framework and Instrumens, by Country

	Foreign Exchange Intervention Framework		Main Instruments of Foreign Exchange Intervention				
Country	Rules	Discretion	Spot	Swaps	Nondeliverable Forwards[1]	Options	Others[2]
Brazil	✓	✓	✓	✓	✓		✓
Chile	✓	✓	✓				✓
Colombia	✓	✓	✓			✓	
Costa Rica		✓	✓				
Mexico	✓	✓	✓		✓	✓	
Paraguay	✓	✓	✓		✓		
Peru		✓	✓	✓			✓
Uruguay		✓	✓				

Sources: Central banks; and IMF staff.
[1]Nondeliverable forwards are settled in local currency; they are also referred to as currency swaps.
[2]"Others" includes instruments such as repo and certificates of deposit linked to the exchange rate.

sophistication of the markets and the multiple objectives central banks are trying to achieve. In addition to the level of international reserves, central bank foreign exchange interventions in the spot market affect interest rates in monetary and capital markets. Hence, a few of the region's central banks have introduced instruments to intervene in the foreign exchange market that would reduce not only the pressure on the spot foreign exchange rate but also lessen the distortions of foreign exchange forward market transactions on interest rates in money and fixed income markets, and at the same time, prevent higher hedging costs. Table 3.4 summarizes the various instruments used in Latin America. These practices are then elaborated, and their utilization and frequency are explained.

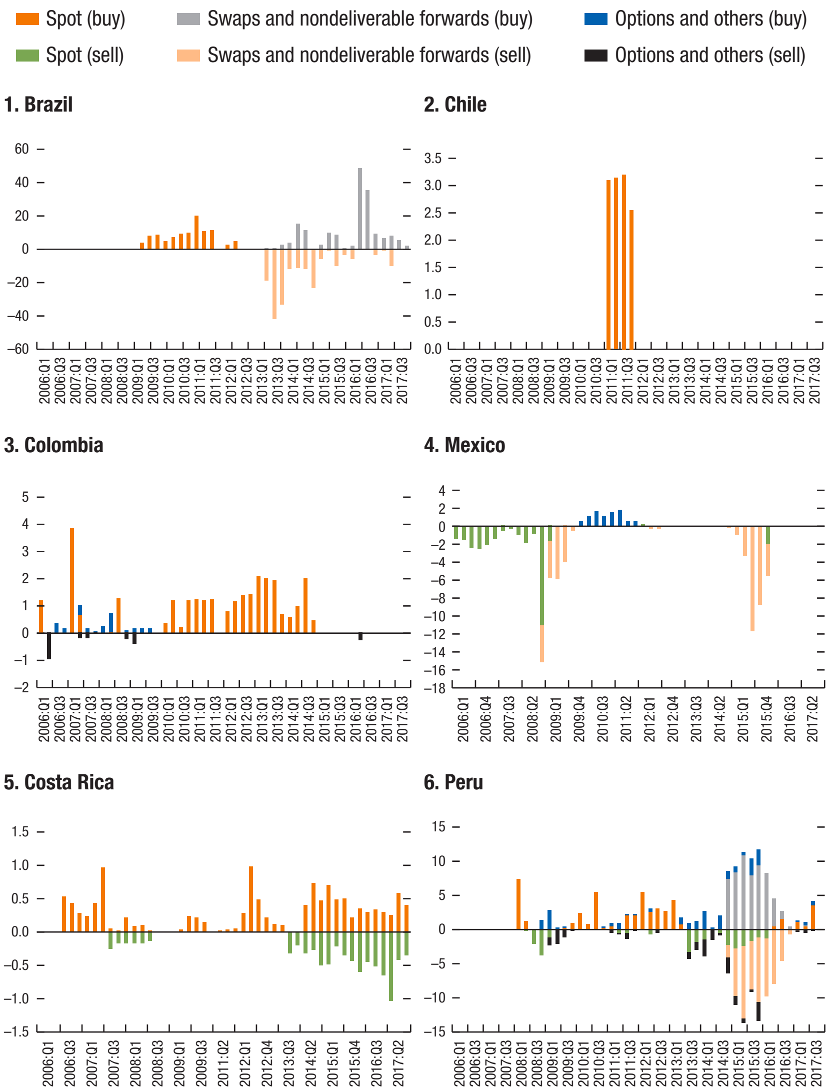
As noted, some countries use a rules-based foreign exchange intervention framework and others use a discretionary-based one. In some instances, countries have even switched from one to the other. The choice of instruments in Table 3.4 in most instances is dictated by the objective and depth of the market, while the choice of foreign exchange intervention framework is mostly influenced by the frequency of interventions.

Regardless of the choice of framework or instrument, most foreign exchange interventions in Latin America have focused on financial stability or on building buffers. In some episodes of large depreciation pressures, price stability has been the objective. Table 3.5 shows the variety of frameworks and instruments Latin American central banks use.

Brief descriptions of country practices follow, with further details in Chapters 7 through 13. See Figure 3.1 for the interventions by instrument and exchange rate.

Figure 3.1. Foreign Exchange Intervention in Latin American Countries, by Instrument and Exchange Rate, 2006–17

(Billions of US dollars, left scale)



Sources: Central banks; and IMF staff.
Note: Data are by quarter for each year.

COUNTRY PRACTICES IN FOREIGN EXCHANGE INTERVENTION

Brazil

The Central Bank of Brazil has intervened in foreign exchange markets since the adoption of the floating exchange regime in 1999. Sterilized intervention in spot markets is one instrument at the central bank's disposal, but by no means the only one. The central bank uses a variety of instruments to intervene in the foreign exchange markets, including outright US dollar sales and foreign exchange repos and swaps. In addition, up to 2002, the central bank was able to use US dollar–linked debt instruments (either issued by the national treasury or by the Central Bank of Brazil) in support of the currency, which directly affected the country's gross debt.

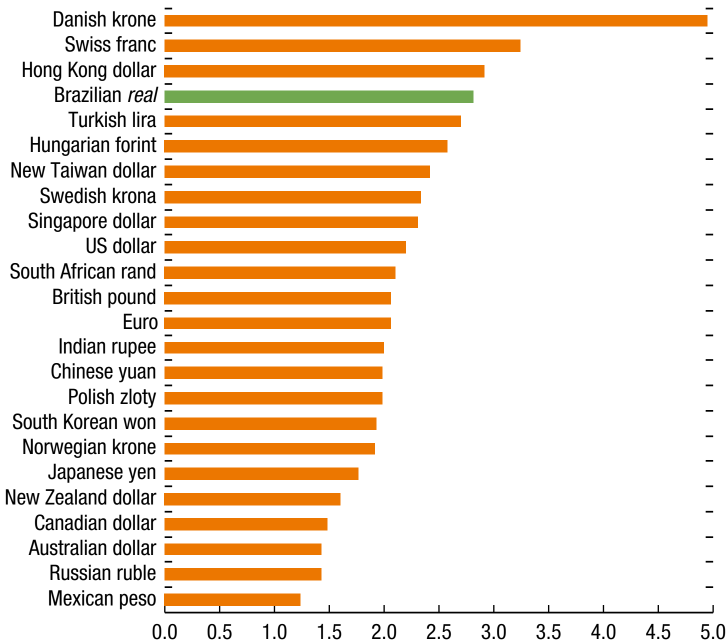
In 2001–02, pressures on the Brazilian *real* intensified amid three major shocks—spillover from the Argentine debt crisis, the 9/11 market jitters in the United States, and public debt solvency concerns following the Brazilian presidential election. The *real* depreciated by up to 44 percent in 2001, and 71 percent in 2002, as international reserves fell to less than $40 billion. The central bank responded by using US dollar–linked debt instruments. However, the Fiscal Responsibility Law, passed in 2002, prohibited the central bank from issuing its own securities beginning in May 2002. Hence, starting in March 2002, the central bank replaced US dollar–linked instruments with so called "Brazilian FX swaps."

In Brazil, spot market transactions are no longer the dominant intervention instrument, mainly because its derivatives markets are among the largest in the world. Trading volumes in derivatives are four times larger than that of the spot market; derivatives markets also lead spot markets into price discovery (see Figure 3.2). The large variety of interventions in Brazil reflects the different central bank objectives, which in turn depend on the period under analysis. During several episodes of market turbulence, the central bank had to counter depreciation pressures and sharp movements of the exchange rate (such as after the election of Lula da Silva in the 2002 election, the 2008 global financial crisis, or the US taper tantrum), while in other circumstances, it seemed to have been weighing against an appreciation of the currency. During 2008–09, the Central Bank of Brazil intervened through a range of tools simultaneously, including spot dollar sales, auctions of foreign exchange swaps and repos, and even indirect US dollar loans to Brazilian firms. Although the central bank has also used repos to provide temporary liquidity to the market, this type of intervention has been limited.

Until recently, the predominantly used instrument has been Brazilian foreign exchange swaps, technically a nondeliverable forward, which factors in the exchange rate risk but is settled in local currency.[2] The instrument requires a high degree of

[2] In Brazil, it is illegal to denominate contracts in foreign currency. Thus, contracts need to be settled in domestic currency even if indexed to US dollars.

Figure 3.2. Ratio of Daily Turnover in Derivatives Market to Spot Market
(Net-net basis, as of April 2013)



Sources: Bank for International Settlements Triennial Survey 2016; and IMF staff calculations.

substitutability—that is, a well-developed derivatives market. From the investor's perspective, the swap is a good substitute for spot US dollars, to the extent that the *real* is fully convertible to US dollars at the date of settlement, thus meeting the demand for hedging. The instrument is structured such that, at maturity, the Central Bank of Brazil pays the international interest rate, i_t^*, plus the actual rate of depreciation, Δe_{t+1}, while it receives the overnight domestic interest rate i_t.

Brazilian foreign exchange swaps provide hedging for investors with open positions, thus directly bidding down the forward exchange rate. At settlement, the Central Bank of Brazil pays its counterparty the additional amount of *reais* necessary to keep the dollar value of the initial open position unchanged. The central bank announces the details of each foreign exchange swap auction one business day before receiving market participants' bids through the *Sistema Especial de Liquidação e Custo* system (known as SELIC). On special occasions, the central bank announces the foreign exchange swap auction for the same day without previous announcement. Until the end of 2015, the notional balance of outstanding foreign exchange swaps amounted to close to $110 billion.

Chile

Chile does not intervene regularly in the foreign exchange market, and its intervention policy has been modest; in past decades, it has intervened sporadically. During 1998–99, interventions were not preannounced and were discretionary. However, in 2001 and 2002, interventions were conducted after a formal policy announcement, under a rules-based framework. These interventions were transparent, including explicit definitions of periods and amounts involved, while clearly explaining the reasons for the interventions. The first of these types of intervention started in August 2001 when the central bank communicated that spot market interventions could occur for up to a maximum of $2 billion over the following four months. Additional sales of $2 billion of dollar-denominated central bank bills were also announced. During that period, spot market interventions totaled $803 million, less than half the maximum announced.

Foreign exchange interventions were again used in 2008 and 2011, but mostly to accumulate reserves. The Central Bank of Chile conducted weekly announced competitive buy auctions of $50 million during the 2011 accumulation program, but it has not intervened in the foreign exchange market since then. Exchange rate movements in Chile allowed for significant current account adjustment, while diluting exchange rate volatility. The central bank usually announces the amount of foreign exchange it intends to buy or sell.

Colombia

The flexible exchange rate regime plays an important role in helping the Colombian economy adapt to changing global conditions. The freely floating

TABLE 3.6.

Colombian Central Bank's US Dollar Auction Program

Start date	October 30, 2015, with subsequent adjustments.
Objective	Moderate disorderly increases in the exchange rate, which might contribute to an unanchoring of inflation expectations, as well as provide liquidity to the foreign exchange market.
Modality	Auction of call US dollar options for about $500 million, which is about one-third of the daily turnover. The option's strike price is the average spot exchange rate on the previous day. Options are sold through Dutch auctions.
Rule based	Trigger for the sale (as well as for the exercise) requires the daily exchange rate movement to exceed a threshold, usually a given percentage relative to the 20-day moving average.
Trigger	On October 30, 2015, a trigger of 7 percent (depreciation in the 20-day moving average) was established. As foreign exchange volatility subsided, the threshold was lowered to 5 percent on December 23, 2015, and to 3 percent on February 19, 2016.
Execution	The auction program has not been triggered yet, which is likely because of the relative stability in oil prices and the program's success in reducing foreign exchange uncertainty.

Sources: Central Bank of Colombia; and IMF staff.

framework has been complemented since October 2015 by a rules-based-contingent foreign exchange auction program aimed at mitigating excess volatility. Colombia experienced a sharp and fast real depreciation of its exchange rate, of about 34 percent, during 2015. This triggered the introduction of a rules-based foreign exchange intervention program through a competitive auction mechanism. The program was introduced in October 2015 (Table 3.6). The rules-based foreign exchange auction program, discontinued on May 31, 2016, was an effective mechanism to prevent disorderly depreciations and was only effectively triggered on May 20, 2016.

Guatemala

Guatemala has a long-standing, rules-based intervention policy that aims to stabilize excessive exchange rate volatility, while not affecting its trend. Intervention is triggered when the weighted average exchange rate of the sell (buy) transactions is less (more) than the five-day moving average reference exchange rate minus (plus) 0.75 percent. If triggered, the central bank offers up to a maximum of five daily auctions of $8 million each.

Mexico

Mexico has a long history of intervention in foreign exchange markets. The modalities of intervention have evolved. During 1996–2001, interventions were predominantly put options, where the central bank bought US dollars mainly to build up reserves. Thereafter, Mexico moved to rules-based intervention to moderate exchange rate volatility and to build international reserves. Table 3.7 presents a recent intervention program, although not the ongoing one.

TABLE 3.7.

Bank of Mexico's Foreign Exchange Intervention Program

Start date	November 29, 2011, with subsequent adjustments.
Objective	Moderate disorderly increases in the exchange rate, which might contribute to an un-anchoring of inflation expectations, as well as provide liquidity to the foreign exchange market.
Modality	Rules-based foreign exchange Dutch auction program provided $400 million call dollar options. The option's minimum price equaled the previous day's benchmark exchange rate plus 2 percent. This rule remained in place until April 2013. In December 2014, the mechanism was reintroduced, but with a reduced amount of $200 million and the previous day's depreciation of 1.5 percent.
Rules based	Trigger for the sale requires the daily exchange rate movement to exceed a threshold, usually a given percentage relative to the previous day.
Trigger	Until 2013, a trigger of 2 percent had been established. As foreign exchange volatility subsided, the threshold was lowered to 1.5 percent starting in December 2014, and to 1 percent starting in July 2015.
Execution	Because the minimum price is set at a fairly large threshold for a one-day depreciation, it was triggered only on a few occasions.

Sources: National authorities; and IMF staff estimates.

In February 2017, they announced a new framework for interventions using NDFs settled in pesos for a maximum \$20 billion; \$1 billion worth of notional principal in short-dollar contracts were auctioned in March, and a new series of auctions were announced in October 2017 to sell NDFs for \$4 billion in seven weekly auctions.

Peru

Peru has had a successful inflation-targeting framework since 2002. The constitution gives the Central Reserve Bank of Peru the mandate to preserve monetary stability, a goal achieved during the last 2 ½ decades. The central bank has had an active policy to moderate foreign exchange volatility to limit the negative effects of large exchange rate fluctuations. Interventions are made frequently using spot interventions, NDFs (also referred to as currency swaps), and certificates of deposit indexed to the exchange rate. Spot interventions are invariably performed during a fixed, preannounced, 2-hour window at the end of each trading day.

Peru's foreign exchange market is composed of spot and derivatives, but the latter is shallow and relatively illiquid, even though most traded instruments in the derivatives market are NDFs. As such, commercial banks are used to selling (buying) US dollars in the foreign exchange forward market, hedging their positions by buying (selling) dollars in the spot market, and thus affecting the spot rate. The forward price (spot rate and forward rate differential) may therefore vary considerably according to the demand and supply of US dollars in the forward market; they typically deviate from the covered interest rate parity. These deviations used to produce profitable arbitrage opportunities. However, the central bank introduced a new instrument to reduce pressure on the spot exchange rate, and at the same time, lessen the distortions of the foreign exchange forward market transactions on interest rates in money and fixed income markets, while preventing the rise of hedging costs. So, in September 2014, the central bank added the Central Reserve Bank FX Swaps (SC BCRPs) as an instrument of foreign exchange intervention. SC BCRPs are basically NDFs settled in local currency.

SC BCRPs are derivatives instruments. One party commits to pay a variable interest rate in the local currency, calculated by using an overnight index swap (built by accumulating the daily interbank interest rate). The other party commits to pay a fixed interest rate in foreign currency and the foreign exchange rate variation. At maturity, the settlement is made by netting positions paid in local currency.

SC BCRPs help to control the foreign exchange spot rate, because they allow banks to hedge their positions from their activities in the forward markets without trading US dollars in the foreign exchange spot market. At the same time, they do not affect the money market, because they have no effect on monetary aggregates. As the settlement is on a netting basis, there is no exchange of notional amounts, either at the beginning or at the maturity of the contract. SC BCRPs are placed under an auction mechanism (the foreign fixed interest rate) that is carried out by the central bank.

Paraguay

The Central Bank of Paraguay intervenes in the foreign exchange market to smooth seasonal fluctuations and speculative movements under the authority of Article 50 of the Organic Law of the Central Bank of Paraguay (489/95), Article 3 of which aims to preserve and safeguard the stability of prices and to promote the efficiency and stability of the financial system. The central bank is constantly involved in the foreign exchange market by either buying or selling US dollars. In recent years, such involvement resulted in a substantial accumulation of international reserves.

The central bank uses two mechanisms to intervene in the foreign exchange market: (1) preannounced sales of the US dollars it receives from the ministry of finance to exchange into guaraníes to support its public expenditures; and (2) discretionary interventions, without previous announcement, to address any abrupt market movements. Under the first mechanism, the central bank announces monthly the frequency and size of the following month's sales. However, the amount is made at the central bank's discretion and should not exceed the current year's US dollar proceeds bought from the ministry of finance.

CONCLUSIONS

This chapter aimed mainly to explore and present a taxonomy of the different dimensions of foreign exchange intervention implementation. Some of the differences could be attributed to country-specific characteristics, others to the goal or strategy of a central bank to achieve its highest efficacy, which can change over time.

Central banks can differ in the transparency of foreign exchange interventions, for example, in policy transparency or operational transparency. In Latin America, policy transparency is observed more often than not. Operational transparency is used less frequently, to mitigate potential idiosyncratic arbitrage opportunities that could undermine intervention effectiveness.

Regardless of the degree of transparency of foreign exchange intervention, another dimension in this taxonomy is whether the central bank operates under a rules-based or discretionary framework. If under a rules-based framework, foreign exchange intervention oftentimes establishes clear thresholds to trigger the intervention in the market. It can even specify the type and volume of the intervention. At the other extreme, sometimes we have observed Latin American central banks to intervene in a discretionary manner, with no precommitment or announcement. The use of rules and discretion vary by country and over time. Moreover, most countries in the region have used discretion at some point in time and a rules-based framework at others. The costs and benefits of each of these frameworks depend on time-varying needs, the type of shocks to which countries are exposed, the nature of the monetary policy framework in place at that time, and the development of a country's financial markets, among other things.

For example, in the aftermath of the deepest financial crisis in recent history, emerging market economies experienced large shifts in foreign exchange market conditions, and many central banks adjusted their market operations to the evolving market and policy backdrop. In some cases, concerns for financial stability led to more frequent use of discretionary and less transparent foreign exchange intervention than before. Large and rapidly shifting capital flows and widening currency mismatches seem to have added support to policies aimed at containing exchange rate volatility and providing the private sector with insurance against exchange rate risks.

Going into a more operational territory, we then delve into the details of the type of instrument and modality used for the foreign exchange intervention. Latin America has extensively used a wide variety of intervention instruments, including forwards, swaps, repos, NDFs, and options, as well as US dollar–linked debt. More than one of these instruments has been used by the region's central banks because of the structure and growing sophistication of their financial markets and the multiplicity of objectives.

Furthermore, to avoid affecting the monetary policy stance when intervening, as given by the market interest rate, central banks have been driven to use instruments that reduce the pressure on the spot foreign exchange rate, while reducing distortions from foreign exchange forward market transactions on interest rates. The choice of instrument has also affected the objective of the intervention, which spans from financial stability (the most frequent one), to building buffers, and in some episodes of large depreciation pressures, price stability (to mitigate the effect and potential nonlinearity of the exchange rate pass-through to domestic prices).

Thus, the wide arrangement of instruments, modalities, and frameworks for foreign exchange intervention in Latin America reflect the permanently shifting needs, structural country characteristics (such as financial deepness and global integration), and short-run objectives of countries in the region. It is not surprising that the taxonomy of foreign exchange interventions is extensive. Using this taxonomy as an encompassing framework, Chapters 7 through 13 detail interventions in Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, and Uruguay, respectively.

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CHAPTER 4

The Effectiveness of Intervention

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This chapter surveys the empirical evidence on the effectiveness of foreign exchange intervention. There is an inherent identification problem when estimating the effect of intervention on the exchange rate, and several econometric techniques have been used to tackle it. Results vary widely, however; some studies find little or no effect, and others find sizable effects. The results are particularly mixed for the impact on the volatility of the exchange rate. Overall, the literature indicates that intervention has more traction when it is preannounced, that foreign exchange sales tend to be more effective than purchases, and that intervention through derivatives has an impact similar to that of spot interventions.

INTRODUCTION

Interventions in the foreign exchange market may entail considerable costs, as Chapter 2 discusses. So why are central banks willing to incur these costs? In other words, what is known about the effect of foreign exchange interventions? To what extent are interventions indeed effective in moving the exchange rate and instrumental in achieving the motivating objectives discussed in Chapter 2?

In theory, it is reasonable to expect unsterilized interventions—which directly affect domestic liquidity conditions and the interest rate differential with foreign markets—to substantially and durably affect the exchange rate. However, the effectiveness of sterilized interventions, which are designed specifically not to affect monetary aggregates or interest rates, is much less clear. Sterilized interventions are the instrument of choice for the inflation-targeting central banks in Latin America.

A considerable and growing literature empirically assesses the effectiveness of sterilized foreign exchange interventions, including several studies on Latin American economies that have accessed the intervention data published by the main central banks in the region. This chapter reviews the literature but first briefly discusses the substantial methodological challenges associated with the empirical work on interventions.

The opinions expressed in this chapter are the sole responsibility of the authors.

ENDOGENEITY

As already noted, assessing the effectiveness of foreign exchange interventions is empirically challenging. This is because of an inherent endogeneity problem when trying to estimate the effect of intervention on the exchange rate. If a central bank wants to smooth shocks to the exchange rate through intervention, it will buy (sell) foreign exchange when the currency faces appreciation (depreciation) pressures. Suppose that intervention does indeed have traction, and the central bank perfectly succeeds in that effort; in that case the data would show a relatively stable exchange rate, along with purchases and sales of foreign exchange, which would bias the econometric results toward zero. Or even worse, suppose that intervention has traction but can only partially smooth the shock; in that case, during periods of appreciation pressures, the data would show an *appreciation* of the exchange rate combined with *foreign exchange purchases*, and vice versa during periods of depreciation pressures. The result can point to intervention having the “wrong” sign, because of the observed correlation of intervention and the trend in the exchange rate. Simple ordinary least squares (OLS) cannot reliably identify the causation between these two variables.

One technique often used to overcome this endogeneity problem is instrumental variables (IVs), which can flip the “wrong” sign obtained from OLS estimates. A good IV would explain the decision to intervene but would not directly affect the exchange rate through other channels. The IV estimates would rely on the changes in intervention that can be explained by that instrument. But a major challenge is to find good instruments. The literature often uses volatility as an instrument, but that is far from ideal. Some instruments can provide stronger identification, such as the use in Blanchard, Adler, and de Carvalho Filho (2015) of capital flows to other countries. However, they are not available at high frequencies. Although IV techniques help sharpen identification (typically yielding stronger results than OLS), it is not clear how far they go to address the inherent endogeneity problem.

Other studies have used vector autoregressive, vector error correction, and structural vector autoregressive models, which can, in principle, capture how the exchange rate and intervention affect each other. However, their success will depend on whether the model’s structure correctly captures the relationship between these variables, which can be a challenge. For example, the decision to intervene may be driven by sustained appreciation, by perceptions of misalignment, or by concerns about the future rather than by recent movements in the exchange rate. Similarly, the response of the exchange rate to intervention could stem from expectations about future intervention through a signaling channel, which may not be fully captured by recent intervention.

Some episodes of intervention lend themselves to event-study analysis, which could also help mitigate endogeneity issues. Most of the largest economies in the region have, at different points, announced changes to foreign exchange intervention rules. One can gauge the effect of that policy change by comparing the behavior of the exchange rate before and after the announcement. The event study can control for other variables affecting the behavior of the exchange rate around the announcement. Some authors have also used a synthetic control approach for major announcements, where a counterfactual exchange rate is constructed based on the experience of peer countries.

In principle, these strategies can help overcome the identification problem, provided that the announcements were indeed the major news affecting the exchange rate. The drawback is that this works only when there is a large preannounced shift in intervention policy. Another concern is that the effect is gauged on the basis of the aftermath of the announcement before most of the intervention takes place (and portfolio balance effects materialize). Although the exchange rate is a forward-looking variable, and markets would price that future intervention, the transmission may not be complete.

An important empirical issue is whether an estimated effect of interventions is permanent or temporary. This is inherently difficult to measure given the very nature of the exchange rate's stochastic process. Error bands will increase over time (they increase with the square root of time, in the case of a random walk). As a result, any estimated impact will eventually be swamped by that uncertainty. Attempts to estimate the persistence of an effect will likely be driven by the assumptions imposed on the estimation model (for example, treat all changes as permanent). The question of persistence is very important from a policy perspective. If a central bank incurs costs to intervene, any cost-benefit analysis will depend on how durable those benefits are. Even if intervention is effective on impact, it may not be worthwhile if the costs are persistent while the benefits are transitory. From a theoretical perspective, if intervention has traction through a signaling channel, that effect should eventually fade as agents receive more and more information, and the original signal loses its relevance. However, the portfolio balance channel could have a permanent effect—for example, if the central bank makes a sterilized purchase of foreign exchange and holds on to it, it will have permanently affected the relative supply of local and foreign currency assets. However, it will be very difficult, if not impossible, to empirically ascertain the persistence of that effect.

The inherent endogeneity problem complicates the research into the effects of foreign exchange interventions. What can be ascertained with some confidence, however, is that the bias involved tends to attenuate the effect of intervention, as discussed earlier. Studies that find an effect do so despite that attenuation bias.

THE EFFECTIVENESS OF FOREIGN EXCHANGE INTERVENTION

Despite the methodological challenges, the literature on the effectiveness of foreign exchange interventions is substantial. This section discusses this literature, with a focus on studies covering Latin America. A relatively large number of studies have looked at Latin American countries over the past 10–15 years (the period in which many countries transitioned to inflation targeting), facilitated by relatively transparent intervention policies and the public availability of intervention data for several of the region's key economies.

The findings on the effectiveness of intervention are discussed along two main dimensions: (1) the effect on the exchange rate *level*, and (2) the effectiveness in reducing exchange rate *volatility*. In addition, this chapter distills lessons from the literature on the relative effectiveness of specific intervention modalities. It also discusses the available evidence on the impact of capital controls on the effectiveness of foreign exchange interventions as well as the impact of interventions on real variables.

Effect on the Exchange Rate Level

Recent studies have found a wide range of results for the estimated impact of foreign exchange interventions on the level of the exchange rate, depending on the countries and periods considered and methods used (Table 4.1). Overall, the evidence is mixed. For all the countries surveyed, at least one study finds no statistically significant effect. For example, using a sample of 15 countries (many in Latin America), Adler and Tovar (2014) find no effect of foreign exchange intervention on the level of the exchange rate. Similarly, for Colombia, Villamizar-Villegas (2016) and Rincón and Toro (2010) also find no effects. Other papers report regressions with "wrong" signs (such as the domestic currency depreciating after a sale of foreign exchange reserves), possibly because of the endogeneity issues discussed in the previous section. Several other studies do find positive effects, however, and sometimes the estimated impact is quite large.

- **Brazil**: Barroso (2014) finds that a $1 billion intervention in Brazil has an effect on the exchange rate of 0.51–1.18 percent. Other studies that find a significant effect tend to point to smaller estimates (0.25–0.50 percent).
- **Chile**: Pincheira (2013) estimates the effect of a $1 billion intervention on the Chilean peso to be as large as 3 percent in 2008. However, other intervention episodes point to smaller effects.
- **Colombia**: Kuersteiner, Phillips, and Villamizar-Villegas (2016) estimate that a put option (foreign exchange purchase) of about $100 million depreciates the exchange rate by as much as 2 percent. However, other studies fail to find an effect. Echavarría, Melo Velandia, and Villamizar (2014) find that preannounced interventions move the exchange rate by about 0.50 percent per $100 million of intervention.
- **Mexico**: Tobal and Yslas (2016) report impulse response functions when the Mexican peso depreciates 2 percent after a one standard deviation intervention shock.
- **Peru**: Studies typically struggle to find an effect, given the relative stability of the exchange rate. Lahura and Vega (2013) estimate a $25 million intervention moves the exchange rate by 0.1 percent.

TABLE 4.1.

Summary of the Literature, by Country

Literature	Period	Type of Intervention	Econometric Method	Estimated Effect
		Brazil		
Barroso 2014	2007–11	Spot and derivatives	GARCH and IV	\$1 billion (spot market) currency appreciates/depreciates by 0.51 percent to 1.18 percent
Chamon, Garcia, and Souza 2017	2013–15	Derivatives and loans in dollars	Synthetic control approach	Announcement of the \$50 billion program, 10 percent appreciation over several weeks
Kohlscheen and Andrade 2014	2011–13	Derivatives	GARCH, VAR, and intraday data	\$1 billion (spot market); 29 basis points appreciation/depreciation
Kohlscheen 2013	2002–11	Spot	OLS	When the central bank does not intervene: 1 percent appreciation of the *real* requires that final customers sell \$2 billion; when the central bank does intervene: 1 percent appreciation requires that final customers sell \$5.5 billion
Marins and others 2017	2006–13	Derivatives	Event study	No effect
Moura, Pereira, and de Moraes Attuy 2013	1999–2012	Derivatives	Propensity score matching	No effect on the level; increases volatility
Nedeljkovic and Saborowski 2017	2008–13	Spot and derivatives	Variety of generalized method of moments (CUE)/IV	\$1 billion spent; 1 percent appreciation and 2.5 percent reduction of implied volatility
de Roure, Furnagiev, and Reitz 2015	2009–12	Spot	SVAR	Indirect effect only
Stone, Walker, and Yasui 2009	2007–09	Spot, derivatives, and loans in dollars	IV with lagged variables as instruments	\$1 billion (spot market) appreciation of 0.3 percent to 0.4 percent Announcement of swap line lowers volatility by 6 percent to 9 percent

(continued)

TABLE 4.1. ***(continued)***

Summary of the Literature, by Country

Literature	Period	Type of Intervention	Econometric Method	Estimated Effect
		Chile		
Tapia and Tokman 2004	January 1998–February 2003, daily	Spot	2SLS	1998–99: sale of $500 million, 1 percent appreciation 2001: no significant impact Similar results with bond sales; significant and negative impacts in 1998; nonsignificant impacts in 2001 and 2002 Significant effect of public announcement of a cumulative appreciation of 2.7 percent and 0.5 percent in 2001 and 2002, respectively Programs not to exceed sale of $4 billion each
Broto 2013	January 2004–June 2011, daily	Spot	GARCH and IV	Intervention has no significant effect on the exchange rate level; both purchases and sales increase their volatility
Pincheira 2013	January 2005–February 2012, daily	Spot	Maximum likelihood estimation	2008: purchase of $1 billion, 3 percent depreciation 2011: no significant impact Announcement effect: purchase of $1 billion announced; 0.3 percent depreciation

(continued)

TABLE 4.1. ***(continued)***

Summary of the Literature, by Country

Literature	Period	Type of Intervention	Econometric Method	Estimated Effect
		Colombia		
Kamil 2008	2004–15, daily	Discretionary spot to manage appreciation	Two-stage IV, censored model, and GARCH	A $100 million purchase depreciates the exchange rate by 0.76 percent; it reduces the variance by 0.02 percent
Echavarría, Melo Velandia, and Villamizar 2014	2000–12, daily	Spot and options	Event study with sign tests	Only foreign exchange sales through options affect the level of the exchange rate
Kuersteiner, Phillips, and Villamizar-Villegas 2016	2001–12, tick by tick	Rules-based options	Regression discontinuity method	Put option auction depreciates the exchange rate by 0.8 percent immediately; the effect peaks at 2 percent in 5 days; no effect of call options (average auction size = $116 million)
Echavarría, Melo Velandia, and Villamizar 2014	2003–12, daily	Discretionary spot vs. preannounced spot	Two-stage IV, censored model, and GARCH	Preannounced intervention depreciates the exchange rate by 0.55 percent, 3.3 times more than discretionary intervention (which is less statistically significant)
Rincón and Toro 2010	1993–2010, daily	Spot and options	Two-stage IV, censored model, and GARCH	No effect on level; intervention increases volatility
Villamizar-Villegas 2016	1999–2012, daily	Spot and discretionary options	Estimation of foreign exchange intervention shocks in first stage; second stage estimates effect on exchange rate, conditional on policy surprises	No effect on level; volatility falls by 0.5 percent

(continued)

TABLE 4.1. ***(continued)***

Summary of the Literature, by Country				
Literature	**Period**	**Type of Intervention**	**Econometric Method**	**Estimated Effect**
		Mexico		
Domaç and Mendoza 2004	August 1996–June 2001, daily	Spot	GARCH and IV	Net sale of $100 million, 0.08 percent appreciation Sale of $100 million, 0.9 percent appreciation Purchase of dollars has no effect
Guimaraes and Karacadag 2004	August 1996–June 2003, daily	Spot	GARCH and IV	Sale of $100 million, 0.4 percent appreciation Purchase of dollars has no effect Sale of dollars has increased both short- and long-term volatility
Tobal and Yslas 2016	January 2000–December 2013, monthly	Spot	SVAR	Net purchase of dollars depreciates the peso; the effect lasts for about 2 months
García-Verdú and Zerecero 2013	October 2008–April 2010, intraday	Spot	Event study	Significant reduction of bid-ask spread in response to a dollar auction with no minimum price
Broto 2013	July 1996–June 2011, daily	Spot	GARCH and IV	Net dollar purchases have no significant effect on the exchange rate level or volatility When sales and purchases looked at separately, both reduce exchange rate volatility
Chamon 2015	2011–15	Spot	Event study	Announcement effect: 3 percent appreciation in the aftermath of a $3.2 billion sale program; 2 percent appreciation in the aftermath of $8.4 billion sale program

(continued)

TABLE 4.1. *(continued)*

Summary of the Literature, by Country				
Literature	**Period**	**Type of Intervention**	**Econometric Method**	**Estimated Effect**
		Peru		
Mundaca 2011	2004–09	Spot	EGARCH	Interventions have an impact only during the intervention window; no long-lasting effects
Lahura and Vega 2013	2009–11	Spot	Event-style regression/SVAR	Sale of $25 million appreciates the exchange rate by 0.1 percent
Humala and Rodríguez 2009	1993–2007	Spot	Univariate and multivariate time series models, subject to stochastic shifts	Interventions seem more effective in periods of high volatility; specific estimation outputs are not provided
Tashu 2014	2010–13	Spot	Author uses volatility in morning hours to estimate the central bank's reaction function; and uses the predicted likelihood of intervention as an instrument	Foreign exchange sales (dummy = –1) appreciate the exchange rate by 0.14 percent; purchases (dummy = 1) depreciate the exchange rate by 0.02 percent
Broto 2013	January 2000–June 2011	Spot	GARCH and IV	Net dollar purchases have no significant effect on the level of the exchange rate, but they lower its volatility; when sales and purchases are looked at separately, both reduce exchange rate volatility

Source: Authors' compilation.

Note: 2SLS = two-stage least squares; CUE = continuously updated estimator; EGARCH = exponential generalized autoregressive conditional heteroskedasticity; GARCH = generalized autoregressive conditional heteroskedasticity; IV = instrumental variable; OLS = ordinary least squares; SVAR = structural vector autoregression; and VAR = vector autoregression.

Although these studies find substantial intervention effects, they are on the upper end of the estimates for these countries.[1] If differences in estimates across studies were normally distributed, the largest estimates would be discounted as outliers. However, given the endogeneity and attenuation bias involved, large point estimates could be at least partly driven by the success of these studies to tackle the identification problem.

The average net foreign exchange purchases were substantial in these five economies. For example, over 2010–12, average yearly net purchases were about $35 billion in Brazil, $4 billion in Chile and Colombia, $20 billion in Mexico, and $6.5 billion in Peru. Multiply these average yearly intervention figures by the point estimates above, and the implied effect would range from 12 percent to 26 percent depreciation of the exchange rate on that year. This suggests foreign exchange interventions may have had a substantial effect on the evolution of the exchange rates. Two important caveats are in order. First, this back-of-the-envelope calculation is based on the upper range of estimates from the studies reviewed (and on the lower end of estimates, there are other studies that point to no effect). Second, and perhaps more important, it is not clear whether the effect on the exchange rate is permanent or transitory, which is subsequently discussed in more detail.

The Effect on Exchange Rate Volatility

A second, frequently cited objective of foreign exchange intervention is to limit the excessive volatility of the exchange rate. Empirical examination of the effect of foreign exchange intervention on exchange rate volatility is, however, subject to two challenges. First, in the empirical literature, volatility is often associated with the variance of the shocks or with the option-implied parameter for the standard deviation of the exchange rate stochastic process. In practice, authorities are more likely to be worried about sharp movements in the exchange rate—a risk that may be better captured by measuring sizable deviations from the equilibrium level, rather than by these traditional measures of volatility. Second, most papers tend to focus on the immediate, short-term effect of intervention on volatility. In practice, however, there could be separate short- and long-term effects. Although intervention may increase volatility on impact (including if it succeeds in facilitating a correction in the level), it may lower volatility in the medium to long term, reflecting central banks' commitment to use foreign exchange intervention in response to large movements or the perception of disorderly market conditions.

A few recent studies that use deviations from equilibrium as a volatility measure have found interventions to be effective. For example, Adler and Tovar (2014), in a study covering 15 countries, including several in Latin America, estimate the effect of intervention on the pace (or acceleration) of appreciation of

[1] Few studies seem to exist on Costa Rica and Uruguay. Refer to Chapter 10 on Costa Rica and Chapter 13 on Uruguay for a detailed discussion of the effectiveness of intervention in these countries.

exchange rates after global shocks, and they find that interventions are effective in reducing this pace—and thus in limiting deviation from the equilibrium exchange rate. Fratzscher and others (2019) use exchange rate variation as a measure of volatility and also find intervention effective for smoothing exchange rates (comparing exchange rate changes over five trading days before and after intervention) in a larger sample of countries.

Most studies, however, define volatility more traditionally as the standard deviation of daily exchange rate returns, with mixed results. Berganza and Broto (2012) find a positive effect of foreign exchange intervention on exchange rate variance; they estimate interventions in inflation-targeting countries (mainly in Latin America) to be more effective in lowering volatility than in non–inflation-targeting countries.

Similarly, Nedeljkovic and Saborowski (2017) also find that foreign exchange intervention (both in spot and nondeliverable futures) was effective in reducing implied volatility in Brazil (with a 2.5 percent reduction in volatility per $1 billion spent). For Peru, Tashu (2014) estimates that foreign exchange interventions in the a.m. sessions reduce volatility by up to 0.14 percent between a.m. and p.m. trading sessions.[2] In Colombia, Kamil (2008) shows that intervention reduced volatility when purchases were made during a period of monetary easing. However, interventions were ineffective in a period of monetary tightening, when markets may have viewed large interventions to curb appreciation to be incompatible with meeting the inflation target in an overheating economy. Furthermore, Villamizar-Villegas (2016) finds that a $100 million sterilized purchase reduces realized volatility, measured by a squared log change in the daily exchange rate, by up to 0.5 percent in Colombia. Domaç and Mendoza (2004) and Chamon (2015) find that interventions also reduce statistical volatility in Mexico.

On the other hand, several other papers find that interventions have no significant effect and sometimes even an adverse effect on traditional measures of volatility. For example, Moura, Pereira, and de Moraes Attuy (2013) and Stone, Walker, and Yasui (2009) find higher volatility in response to futures market intervention in Brazil. Rincón and Toro (2010) find that intervention increases volatility significantly in Colombia. Furthermore, foreign exchange sales are found to increase both short- and long-term volatility in Mexico (Guimaraes and Karacadag 2004).

One reason for the wide range of estimates on the effect of intervention on volatility could be the use of different estimation methods and identification strategies. However, Broto (2013), who uses a homogeneous model to assess effectiveness of intervention in Chile, Colombia, Mexico, and Peru, also finds a

[2] The foreign exchange market in Peru operates between 9:00 a.m. and 1:30 p.m. local time. Volatility is measured by the square root of the squared deviation of the exchange rate from the weekly average exchange rate. The paper uses exchange rate movements during the a.m. session to estimate the Central Reserve Bank of Peru's reaction function. Predicted values from these reaction functions are then used as instruments for interventions in the regressions for changes in exchange rate volatility between the a.m. and p.m. sessions.

wide range of results for the countries in her sample. Specifically, Broto finds that intervention leads to higher volatility in Chile, and that although both purchases and sales lower volatility in Mexico and Peru, only purchases do so in Colombia. Thus, results are mixed even when using a consistent empirical method across countries.

Several papers suggest that the effectiveness of intervention in dampening volatility operates through the signaling channel. For example, Mundaca (2011) shows that publicizing information about past interventions has strengthened the effectiveness of interventions and lowered exchange rate volatility in Peru (albeit for very short time periods). Furthermore, Broto (2013) finds for the four countries in her sample that first interventions, whether isolated or under a rule, reduce volatility and that the size of intervention plays only a minor role, which also suggests that interventions work mainly through the signaling channel.

Duration of Effects

Most studies do not attempt to measure the persistence or duration of the effect of intervention. This is likely because of the methodological constraints discussed earlier. Among the studies that try to address duration, some find effects to be (very) short lived. For example, Mundaca (2011) uses high-frequency data and finds that interventions in Peru have no effect past the two-hour window during which the central bank intervenes. Similarly, Kohlscheen and Andrade (2014) find no significant effect of intervention in Brazil on the exchange rate levels after 90 minutes. However, other studies find more persistent effects. For example, Tobal and Yslas (2016) use a structural vector autoregressive model framework and estimate the effect of interventions on the exchange rate level to last about two months in Mexico and one month in Brazil. Echavarría, Melo Velandia, and Villamizar (2014) estimate the effect of interventions through volatility options to be effective for periods of up to 25 days in Colombia—a result that is corroborated by Villamizar-Villegas (2016). For Brazil, Chamon, Garcia, and Souza (2017) also find effects to last several weeks.

MODALITIES OF INTERVENTION AND EFFECTIVENESS

Since the modalities of intervention differ between countries and over time, a comparison of the various studies for Latin American countries also sheds some light on the relative effectiveness of different types of intervention on the exchange rate level.

Purchases versus Sales

In principle, it is not clear that the effects of foreign exchange sales and purchases should be asymmetric. There are theoretical arguments supporting the effectiveness for both sales and purchases. As discussed in Chapter 2, intervention has traction in a setting where capital flows respond to return differentials, but at a finite pace (unlike a setting where uncovered interest rate parity (UIP) holds and flows would come until the return differential is arbitraged away). An asymmetry in the effect of intervention sales and purchases could come from flows being more responsive to returns or conditions at times of appreciation pressures, or vice versa. For example, it could be that during "risk-on" periods, capital flows are more sensitive to the effect of intervention than during "risk-off" episodes. Also, interventions may have more traction under disorderly market conditions, which are more likely to be associated with depreciation pressures. During such episodes—associated with foreign exchange sales by the central bank—the authorities typically intervene in large amounts, aiming explicitly at influencing market prices. Such a pattern of intervention could be expected to have a stronger effect on the market, including through signaling effects, than that of a central bank that is gradually accumulating foreign reserves (that is, purchases) in an environment of appreciation pressures.

Foreign exchange sales might also send a stronger signal because selling foreign reserves is costlier for the central bank than buying reserves, since foreign currency is a limited resource. It could be argued that foreign exchange sales reveal a significant disagreement of authorities with the current exchange rate and thus send a strong signal to markets (provided there are sufficient reserves to follow through). However, a central bank seeking to stem appreciation pressures by buying foreign exchange could, in principle, do so in unlimited amounts, which is highly credible and could therefore also imply a strong signal.

Several studies explore asymmetries in the effects of interventions that buy and sell foreign exchange. Most of these (such as Kohlscheen and Andrade (2014) for Brazil, Broto (2013) for Chile, Domaç and Mendoza (2004) for Mexico, and Lahura and Vega (2013) and Tashu (2014) for Peru) find that foreign exchange sales have a larger effect than foreign exchange purchases. However, Echavarría, Melo Velandia, and Villamizar (2014) and Kuersteiner, Phillips, and Villamizar-Villegas (2016) find stronger effects of purchase interventions (put options to buy foreign exchange) in Colombia.

Spot versus Derivative Interventions

While most studies focus on spot interventions, a few cover episodes of derivative interventions. These studies mostly find derivative interventions to be either similar or less effective than spot interventions. For example, Nedeljkovic and Saborowski (2017) show, for Brazil, that \$1 billion of interventions on the spot market impacts the exchange rate by 1 percent, a statistically indistinguishable effect from the change of 0.7 percent resulting from interventions through derivatives. Similarly, Barroso (2014) finds that \$1 billion of interventions on the spot and derivatives market affect the exchange rate by 0.51 and 0.31 percent, respectively. In an event study, Echavarría, Melo Velandia, and Villamizar (2014) find that intervention through options is more effective than other types of intervention, in the sense that it delivers the intended outcomes more often (they focus on appreciation/depreciation events, not on the magnitudes of them).

Preannounced versus Discretionary

The literature also suggests that preannounced interventions are generally more effective than discretionary ones. For example, Echavarría, Melo Velandia, and Villamizar (2014) find that preannounced interventions in Colombia have three times more traction. In a related vein, several studies examine the direct effect of announcements themselves. Stone, Walker, and Yasui (2009), who compare the effect of announcements versus actual interventions in Brazil, conclude that announcements are significantly more effective than interventions themselves. For Chile, Fuentes and others (2014) find that although the effect of actual interventions is transitory, the effects of the announcements of intervention programs are both significant and persistent. This result is consistent with Tapia and Tokman (2004), who found that intervention announcements—not necessarily the actual interventions—were the main policy instrument affecting the exchange rate in Chile in 2001–02. Chamon (2015) also estimates a sizable effect of announced changes in foreign exchange intervention rules in Mexico. And Chamon, Garcia, and Souza (2017), who use a synthetic control approach to estimate the effect of the announcement of a large intervention program in Brazil, show that the exchange rate responded strongly after the announcement of the program, even though the pace of intervention actually declined (the central bank was intervening even more heavily prior to the announcement, but in a discretionary fashion and failing to revert the depreciation pressures).[3] While preannounced interventions should have an effect similar to that of discretionary interventions through a portfolio-balanced channel, the aforementioned evidence suggests that preannounced intervention may have a stronger effect through the signaling channel.

Interventions and Capital Controls

Several studies explore the effectiveness of interventions in relation to capital account openness. More capital mobility can help make domestic and foreign assets closer substitutes, which could reduce the effect of foreign exchange intervention through the portfolio balance channel. In contrast, it may be more difficult for capital flows to offset the effect of intervention in a closed economy (where frictions can make "quantities"—that is, intervention—play a relatively larger role in shaping the foreign exchange market for a given interest rate differential). In line with this theory, Adler and Tovar (2014) find that financial openness (measured by the Ito-Chinn Index) reduces the effect of intervention.

[3] This pattern could be the result of the program committing to a larger stream of interventions than the market was expecting under discretionary interventions.

Similarly, for Colombia, Rincón and Toro (2010), conclude that foreign exchange interventions are effective only when used in conjunction with capital controls.

Countries in Latin America, however, are relatively open compared to other regions (and remain so, even during episodes where additional capital controls are imposed). Thus, any additional gain in traction from imposing new capital controls is likely to be small relative to the gains identified in cross-country studies, which may be based on comparisons with economies that are much more closed.

Exchange rate restrictions can also shape the structure and development of the foreign exchange market itself. For example, restrictions on denominating contracts in foreign currency contributed to the development of derivatives markets in Brazil (Garcia and Volpon 2014). The Brazilian market for nondeliverable forwards has become much more liquid than the spot market, and the former is where much of the price discovery process for the exchange rate takes place. This can help explain why derivative interventions are more commonly used in Brazil.

THE EFFECT ON OTHER VARIABLES AND THE ROLE OF MARKET CONDITIONS

Most of the literature on foreign exchange intervention focuses on the effect on the level and volatility of the exchange rate, and little attention is generally given to effects on other variables, such as interest rates, inflation, and inflation expectations. Since the foreign exchange interventions examined are typically sterilized interventions, such an effect on interest rates or real variables would likewise not be expected. A few studies confirm this; for example, Tobal and Yslas (2016) find that foreign exchange interventions are not associated with an immediate expansion in the monetary conditions (that is, an increase in the monetary base and a fall in interest rates) in Brazil and Mexico. Similarly, Villamizar-Villegas (2016) concludes that neither the 1-year Treasury bond yield nor the interbank rate respond to intervention in Colombia. These studies seem to indicate that interventions are indeed sterilized.

However, one study finds that a positive intervention shock leads to a significant increase in credit in Brazil: Garcia-Verdú and Zerecero (2013) present a model in which foreign exchange intervention causes banks to hold more bonds that are issued as part of sterilization. As a result, the portfolio balance channel stimulates banks to increase the supply of loans, substituting away from holding additional bonds. The paper finds this channel to be empirically relevant in Brazil. Pincheira (2013) estimates that in Chile a preannounced intervention program in 2008 had a significant, albeit short-lived, effect on inflation expectations at long horizons, although interventions carried out in 2011 showed no such impact. The effect on inflation expectations might be because interventions lower the credibility of the central bank's inflation-targeting policy, particularly in 2008, when inflation in Chile was already high.

A shortcoming of the literature is that few studies seem to pay much attention to the prevailing macroeconomic and market conditions at the time of intervention. However, as discussed earlier (in the context of the asymmetries between interventions involving foreign exchange sales and purchases), macroeconomic and market conditions should have a considerable impact on the effectiveness of intervention. For example, Adler and Tovar (2014) find that interventions to stem an appreciation are more effective when the real exchange rate is seen as overvalued. Also, Fratzscher and others (2019) and Humala and Rodríguez (2009) find evidence that interventions are more effective in times of market turbulence. Kamil (2008) finds interventions in Colombia contain appreciation pressures that are effective during periods of monetary easing but not during times when the economy is overheating. Most studies, however, do not systematically account for, or control for, the macro and financial environment in which interventions are conducted.

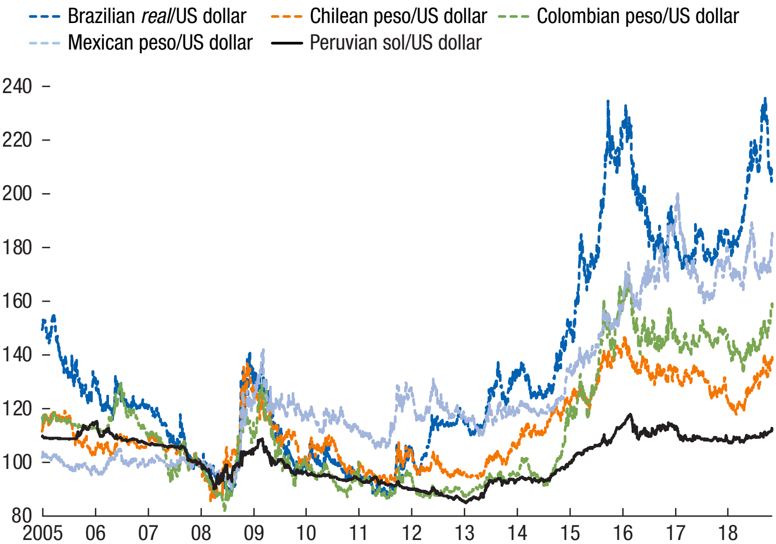
CONCLUSION

Overall, the literature is mixed on the effectiveness of interventions; with the effectiveness of sterilized interventions on the level of (or volatility of) exchange rates ranging from negligible, through counterproductive, to large and positive. The wide range is probably due, at least in part, to the considerable identification challenges for which different authors have used various approaches and instruments, arguably with variable success. A related shortcoming of the literature is that few studies provide meaningful evidence on the duration or persistence of the effect of interventions—which is an important dimension of effectiveness, but difficult to measure.

The fact that many studies do find significant intervention effects against the attenuation bias strongly suggests that interventions have at least some effect. This is consistent with the more informal evidence for effectiveness; for example, Figure 4.1 shows the path of the Peruvian sol relative to its regional peers. Among the Latin American countries considered in this chapter, Peru is particularly active in the foreign exchange market, with frequent daily interventions and a stock of reserves that amounts to more than 30 percent of GDP. And while econometric studies for Peru find variable and often only short-lived effects from these interventions, a glance at the trajectory of the exchange rate over the past decade suggests that the sol exchange rate has indeed been much less volatile than the rates of its regional peers.

It is particularly informative to compare Chile and Peru, given that both countries rely on metal commodity exports, have strong macroeconomic policy management, and are opposites on intervention policy (Peru intervenes frequently and Chile very rarely). The evolution of their respective exchange rates shows that the Chilean peso appreciated more strongly during good times (favorable commodity prices and capital inflows) but also depreciated more strongly under less favorable global conditions. For Peru, while there are many factors that may have contributed to the relative stability of the Peruvian sol, intervention likely played a significant role. Relative exchange rate stability combined with frequent

Figure 4.1. Latin America: Nominal Exchange Rate Indices, 2005–18
(2008 = 100)



Source: Bloomberg Finance L.P.

intervention precludes finding an econometric effect of intervention, for the reasons discussed earlier in this chapter.

The literature sheds limited light on the determinants of intervention effectiveness. As one would expect, interventions seem to become less effective the more open the capital account is. Evidence also suggests that interventions to stem depreciations may be more effective than those countering appreciation pressures, and that announced interventions are more effective than unannounced ones. However, a systematic investigation of the circumstances, specific market conditions, institutional setups, and intervention modalities of each type of intervention, and when each is effective, would fill an important gap in the literature.

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CHAPTER 5

Forward Intervention

Chris Walker

This chapter examines the differences between spot and forward currency interventions by way of a model that incorporates the motivations of different groups of currency market participants. The model concludes that, although spot and forward intervention have equivalent effects on the exchange rate, they have differing effects on forward-implied interest rate spreads and on capital flows. The model offers insights into the relative effectiveness of each type of intervention in response to different external shocks. Regressions that use available forward intervention data from Brazil, Mexico, and Peru support the model.

INTRODUCTION

Forward markets are tempting targets for central bank interventions. In contrast with spot interventions, forward-market interventions are self-sterilizing and do not require transfers of reserves. A further advantage is that forward interventions to sell foreign (and buy local) currency are not limited by the supply of foreign reserves. However, a central bank that proposes to use a forward intervention must consider whether that operation is likely to have the same effect on the exchange rate as the corresponding spot intervention. A related question is whether forward intervention may constitute an instrument that is distinct from spot intervention, with different effects on interest rates and capital flows.

Two recent developments highlight the importance of understanding forward-market intervention. First, a growing number of central banks have used forward intervention either in lieu of, or to supplement, spot market interventions. Among emerging markets, the Central Bank of Brazil is perhaps the most experienced in this regard, but other major central banks, including those of Mexico and Peru, have been increasingly active in forward markets. Second, substitutability between spot and forward markets, although still high, appears to have diminished, particularly since the global financial crisis. Consequently, the tight covered interest parity (CIP) relationship has weakened in many currency markets.

This study begins with brief accounts of forward-market intervention, before and after the financial crisis, followed by a review of the covered interest parity hypothesis. It offers possible reasons for the weakening of the CIP relationship,

The opinions expressed in this chapter are the sole responsibility of the author.

which—until recently—was thought to determine prices in currency forward markets. Subsequently, a model is presented that explicitly incorporates different sources of demand for currency forwards and explores its implications for spot and forward interventions. A brief empirical section tests some of the model's implications against recent episodes of forward-market intervention in Brazil, Mexico, and Peru. The conclusion suggests a set of preliminary rules for monetary authorities to use when deciding between spot and forward-market intervention.

FORWARD PRICING AND COVERED INTEREST PARITY

A currency forward (or, in an exchange with tradable contracts, a currency future) is a contract to exchange a given amount of one currency for another at a set price at a specific future date.[1] The relationship between the spot exchange rate and the forward exchange rate is traditionally governed by CIP. In logarithmic form, this can be expressed as follows:

$$f = \left(i - i^{*}\right) + e,$$

where i and i^* are logs of the gross domestic and foreign interest rates, respectively, (approximately equivalent to the respective net interest rates), and e and f are logs of the spot and forward exchange rates (all of them for a common duration, such as one year), expressed in units of local currency per dollar. The relationship has been thought to hold a high degree of precision through an arbitrage argument. If f were to rise much above the value entailed by CIP (so that the local currency becomes weaker than implied by CIP), cross-border arbitrageurs would have an incentive to borrow domestically at i, trade for foreign currency (by convention, US dollars) at exchange rate e, invest abroad at interest rate i^*, and purchase domestic currency back at the weaker rate f, which enables them to repay the domestic loan while realizing a riskless profit. In principle (and different from the case of uncovered interest parity), this constitutes a riskless arbitrage, given that the forward rate is already determined at the time of the trade. A parallel arbitrage argument would hold if f were to fall below the CIP-implied level.

EPISODES OF FORWARD INTERVENTION

Some central banks have benefited from this relationship to conduct foreign exchange interventions in the forward rather than the spot market. If CIP is presumed to hold, a forward sale or the purchase of foreign currency contracts should have the same effect on the spot exchange rate as an equivalent amount of currency traded on the spot market. Some advanced economy central banks have followed this practice, including the Reserve Bank of Australia, which has sometimes

[1] This is not precisely true in the case of nondeliverable forwards, for which the gains or losses at the maturity of a forward contract are settled in a given currency, and there is no exchange of currencies. For this study, nondeliverable forwards are treated as standard forward contracts.

used forward operations when intervening in currency markets (see Becker and Sinclair 2004).[2] The advantage of this approach is that spot interventions need to be sterilized if the operation is not to affect domestic monetary conditions, whereas forward interventions have no effect on the money supply. A further possible advantage is that currency futures markets are, at times, more liquid than the corresponding spot markets.

Brazil has frequently used forward intervention, but has not always treated it as a close substitute for spot intervention. During two periods of strong capital inflows, in 2006–08 and 2009–11, the Central Bank of Brazil accompanied spot market US dollar purchases with a buildup of its long US dollar forward position, which increased its net forward US dollar position from –$12 billion to +$11 billion between January 2009 and April 2011. These interventions were intended not only to keep the spot exchange rate from strengthening too much but also to respond to a rising demand for the Brazilian *real* in the forward market, in some cases from "carry trade" investors. In conducting its forward operations, the Central Bank of Brazil was also mindful of the effect on the *cupom cambial*, the implied US dollar interest rate available to domestic investors that borrow in local currency to obtain dollars and repurchase the domestic currency in the forward market to close out the loan (for a detailed empirical and analytic account, see Garcia and Volpon 2014).Under CIP this rate should equal the US dollar interest rate at the appropriate term, although in practice, this has never been the case; the implied US dollar interest rate in Brazil has always been higher than the onshore US dollar interest rate, which means that Brazil's currency has been stronger in the forward market than would be implied by CIP. By purchasing US dollars forward during periods of capital inflows, the Central Bank of Brazil could reduce the differential between onshore and offshore US dollar interest rates.

Korea's central bank has also intervened in currency forward markets in response to imbalances (Baba and Shin 2011). As in Brazil, the domestic currency in Korea, the won, has generally been stronger in the forward market than would be implied by CIP. However, in Korea, the demand to sell US dollars and to buy local currency forwards arises largely from exporters (shipbuilders, in particular) who wish to match anticipated US dollar revenues from sales abroad to their local-currency production costs. The forward contracts they purchase are sold by domestic banks, who match the resulting long forward US dollar positions by borrowing US dollars in the spot market from foreign banks. During the 2007–09 global financial crisis, when foreign banks were temporarily unwilling to lend US dollars to Korean banks, the deviation from CIP intensified, which left the won much stronger in the forward market than would be implied by CIP. The Bank of Korea responded with a combination of policy measures, including

[2] To avoid changes in domestic monetary conditions, the Reserve Bank of Australia would combine a spot US dollar sale with a currency swap, resulting in zero net change in its US dollar holdings and a reduction in its forward US dollar position.

the sale of US dollar swaps, which had the effect of filling spot market demand for US dollars while reducing the deviation from CIP.[3]

In recent years, intervention by emerging market central banks in forward markets has often been in response to negative external shocks. This was the case for Brazil in 2013–14—during a period of economic slowdown and some capital outflows—when the Central Bank of Brazil undertook net forward US dollar sales of almost $90 billion, equivalent to one-fourth of its reserve stock. Faced with negative external shocks, Mexico's central bank has, since the end of 2016, engaged in some forward peso purchases. Peru's central bank has managed a forward position for several years. The section on empirical results examines the forward operations of these three central banks in detail.

COST OF ARBITRAGE AND THE WEAKENING OF COVERED INTEREST PARITY

The tight adherence to CIP that formerly characterized major currency markets has markedly weakened since the global financial crisis (Figure 5.1). At the same time, divergences from CIP,[4] prevalent in emerging markets since well before the crisis, have not diminished, and in some cases have intensified. One widely cited explanation for the change in market behavior is that the cost of arbitraging CIP divergences has increased with the postcrisis increase in the cost of bank capital caused by tighter regulations. Tighter controls on cross-border banking exposures in emerging markets may also work to limit arbitrage. Concurrently, demand for currency hedges by nonfinancial corporations has risen, which increases the amount of arbitrage activity needed to restore CIP. These influences are reflected in the model of spot and forward interventions subsequently discussed.

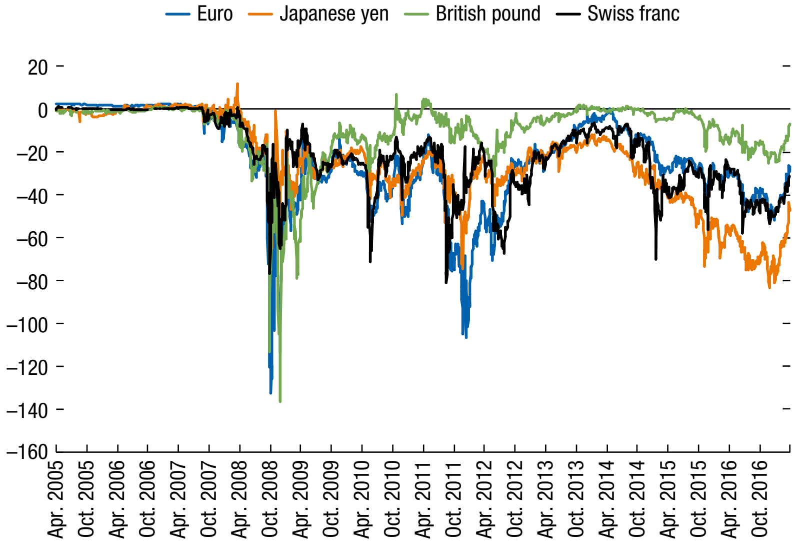
PRESENTATION OF MODEL

The model here recalls the approach of Ghosh, Ostry, and Chamon (2016), who make the case for treating spot intervention as an instrument distinct from the policy interest rate. In lieu of the standard uncovered interest parity assumption, the authors adopt a modified condition that relates capital flows to departures from uncovered interest parity, but it does not assume that uncovered interest parity holds instantaneously and at all times. Their approach is extended here with a similar flow condition in the forward market. An important consequence of these joint assumptions is that neither uncovered interest parity nor CIP is constrained to hold at all times. The possibility of significant departures from CIP

[3] Sales of a US dollar swap by the central bank would entail selling US dollars in the spot market and buying them back in the forward market.

[4] Divergence from CIP determines what is known to market participants as the "basis spread." The terms are used interchangeably in the text.

Figure 5.1. One-Year Cross-Country Basis
(Basis points)



Source: Bloomberg Finance L.P.

reflects conditions that have been prevalent in financial markets since the global financial crisis.

The model is presented in static form, but it presumes a long-term equilibrium, including a long-term equilibrium log real exchange rate $\bar{e}$, assumed to be zero.[5] CIP is not presumed to hold in the long-term equilibrium, although divergences from CIP drive arbitrage flows. Both spot and forward interventions are presumed to be zero in the long-term equilibrium. Scalar values that are not presumed to equal zero in the long-term equilibrium are designated as δ or α. Values corresponding to temporary external shocks are designated by ε and are set to zero in the long-term equilibrium.

The following eight equations provide the basic model structure. Exchange rates are shown in units of local currency per US dollar, so that higher values of e and f correspond to local currency depreciation in spot and forward markets, respectively. Spot and forward exchange rates e and f, and domestic and foreign interest rates i and i^* are given in logs (i and i^* are logs of the gross domestic and foreign real interest rates). The real exchange rate e may differ from the long-run real exchange rate $\bar{e}$.

[5] The long-term equilibrium exchange rate $\bar{e}$ could change in response to a permanent change in fiscal policy, for example, or to a permanent external shock. However, these scenarios are not considered in the present study.

Current Account (CA)

$$CA = \alpha_1 + \beta_1 e + \varepsilon_{CS} \tag{5.1}$$

A depreciation (e up) improves the CA. The ε_{CS} term reflects the effect of commodity price shocks on the CA balance.

Capital Flow Condition (Modified Uncovered Interest Parity)

$$g(i, i^*, e) = \gamma_g(i - i^* + e) + \delta_{OFF} + \varepsilon_{FS} \tag{5.2}$$

A portion of capital inflows is determined by the modified interest parity condition. A higher real domestic interest rate I, relative to the real foreign rate i^*, attracts inflows from nonhedged yield-seeking investors. These investors adjust their expected returns by the expected real appreciation of the exchange rate e, equal to $e - \bar{e}$ (or simply e with $\bar{e}$ set to zero). Additional capital flows not directly linked to interest rates—such as foreign direct investment—are represented by δ_{OFF}, whereas ε_{FS} is a financial shock, assumed to be zero in long-term equilibrium and negative in the event of an externally based financial crisis. A positive figure for g corresponds to an inflow on the capital/financial account.

Synthetic Dollar Borrowing Condition

$$h_{SDB}(i, f, e) = \gamma_{SDB}(-i - e + f) + \delta_{SDB} \tag{5.3}$$

Market participants that need US dollar funding but lack access to offshore capital markets can borrow US dollars synthetically by taking out a loan in local currency, exchanging the proceeds for foreign currency, and repurchasing the local currency necessary to repay the loan in the forward market. This operation generates an outflow on the capital/financial account, and an equivalent inflow in the forward market.

Arbitrage Trade

$$h_{AT} = \gamma_{AT}(i + e - f - i^*) \tag{5.4}$$

These flows arbitrage divergences from CIP. If CIP holds, then the quantity in the parentheses is zero. To the extent that the interest rate available to a hedged foreign investor purchasing assets in the domestic market ($i + e - f$) exceeds the rate at which that investor borrows in the foreign market (i^*), these flows will be larger. A positive value of h_{AT} corresponds to an inflow on the capital account and an outflow in the forward market.

Hedging Demand

$$h_{HD} = \delta_{HD} + \varepsilon_{HS} \tag{5.5}$$

Demand for forward hedges (such as from exporters or importers) is taken to be independent of exchange rate expectations or interest rates. A positive value for h_{HD} in the model is assumed to entail hedging demand to buy dollars and to sell local currency. This would normally be the case for an importer who seeks to ensure the US dollar value of expected future receipts. Accordingly, a positive value of h_{HD} corresponds to an outflow in the forward market. It is also possible, however, that exporters could dominate the hedging market (see the earlier Korean example), in which case, δ_{HD} would take a negative value, as would h_{HD} in long-term equilibrium or in the absence of a shock to hedging demand.

Forward-Market Demand

$$h(i, i^*, e, f) = h_{SDB} - h_{AT} - h_{HD} = (\gamma_{AT} + \gamma_{SDB})(-i - e + f) + \gamma_{AT} i^*$$
$$+ (\delta_{SDB} - \delta_{HD} - \varepsilon_{HD}) \tag{5.6}$$

This combines the three sources of demand for currency forwards, equations (5.3) through (5.5).

Balance of Payments Condition

$$\Delta R = CA + KA = CA + g + h_{AT} - h_{SDB} \tag{5.7}$$

This is the standard balance of payments identity adapted to the model.

Forward-Market Equilibrium Condition

$$\Delta W = h = h_{SDB} - h_{AT} - h_{HD}, \tag{5.8}$$

where W represents the central bank's net forward position.

Algebraic manipulation of equations (5.1) through (5.8) allows derivation of separate closed-form expressions for e and f, in terms of exogenous variables (see annex 5.1). These are summarized in the following (Jacobian) matrix of first derivatives (5.13):

$$\begin{bmatrix} \frac{\partial e}{\partial \Delta R} & \frac{\partial e}{\partial \Delta W} \\ \frac{df}{d\Delta R} & \frac{\partial f}{\partial \Delta W} \end{bmatrix} = \begin{bmatrix} \frac{1}{\beta + \gamma_g} & \frac{1}{\beta + \gamma_g} \\ \frac{1}{\beta + \gamma_g} & \frac{1}{\beta + \gamma_g}\frac{\Omega}{\gamma + \gamma_{SDB}} \end{bmatrix} \tag{5.13}$$

Note that the term $\frac{\Omega}{\gamma_{AT} + \gamma_{SDB}}$ is greater than 1.

RESULTS FROM THE MODEL

Spot and Forward Interventions Have the Same Effect on the Exchange Rate

From equation (5.9), it follows that the effect of a unit change in reserves (that is, in a spot intervention) on the exchange rate is the same as that of a unit change in the central bank's forward position. That is, the model implies that forward intervention is as effective as spot intervention in shifting the spot exchange rate.[6] It also follows from (5.13) that spot intervention has the same effect on the forward rate as it has on the spot rate. An immediate consequence is that spot intervention should have no effect on the divergence from CIP ($i^* - i - e + f$), or "basis spread."

Spot and Forward Interventions Have Different Effects on the Forward Rate and Therefore on the Divergence from CIP

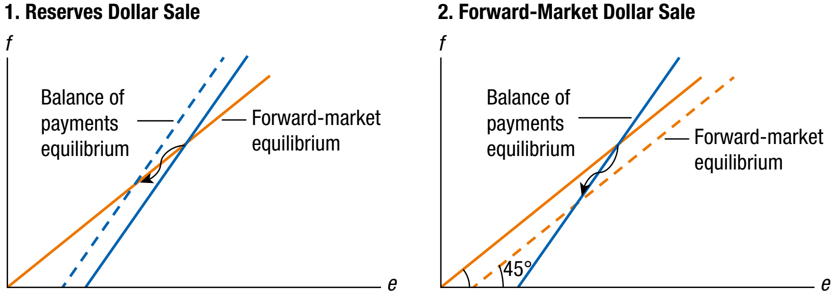
By contrast, a forward intervention does not have the same effect on spot and forward rates. A change in the central bank's forward position has a greater effect on the forward rate than on the spot rate. This implies that a central bank purchase of US dollar forwards will increase the basis spread ($i^* - i - e + f$). In contrast, a central bank sale of US dollar forwards reduces the basis spread, and if the basis spread is negative (as is often the case), it increases the divergence from CIP. This acts to discourage synthetic US dollar borrowing (an outflow) and encourage arbitrage trading. Forward intervention, although it is as effective as spot intervention in shifting the exchange rate, also affects synthetic US dollar borrowing costs (essentially the onshore US dollar interest rate) and capital flows.

Why should this asymmetry between spot and forward interventions exist? Consider the equations for the balance of payments equilibrium (5.9) and the forward-market equilibrium (5.10), depicted in Figure 5.2. If the central bank sells reserves and takes no other action, as panel 1 in Figure 5.2 shows, then the balance of payments equilibrium line shifts to the left. However, the forward-market equilibrium line is unchanged—forward equilibrium will continue to hold only if any change in e is matched by a change in f ($\frac{\partial f}{\partial e} = 1$ along the forward-market equilibrium line). However, if the central bank sells US dollars forward (Figure 5.2, panel 2) and takes no other action, the market moves to a new point along the balance of payments equilibrium line. The decline in f is greater than the decline in e ($\frac{\partial f}{\partial e} > 1$ along the forward-market equilibrium line) and the basis spread widens.[7]

[6] This conjecture is supported empirically in the case of Brazil by Nedeljkovic and Saborowski (2017).

[7] The divergence from CIP must widen to increase arbitrage inflows and decrease synthetic US dollar borrowing, thereby compensating for the negative effect of a stronger exchange rate on trade and other capital inflows (g).

Figure 5.2. Balance of Payments and Forward-Market Equilibrium Scenarios



Source: Authors.

Forward Dollar Sales Induce Equivalent Capital Inflows

Forward US dollar sales induce equivalent capital inflows, whereas spot US dollar sales do not have this effect. Both operations cause the spot exchange rate to strengthen, which reduces both the CA surplus and the modified uncovered interest parity inflows. In the case of spot US dollar sales, the loss in inflows is equivalent to the reserves supplied to the market. Selling US dollars forward, on the other hand, has the same effect on CA and modified uncovered interest parity inflows, but it brings arbitrage flows onshore and does not cost reserves. Equation (5.8) shows a decline of \$100 million in the central bank's forward position ($\Delta W = -100$) , which entails a decline in ($h_{SDB} - h_{AT}$) of \$100 million, relative to the counterfactual in which there is no forward intervention. Equation 5.7 shows that ($CA + g$) must fall by \$100 million, since $\Delta R = 0$, and ($h_{AT} - h_{SDB}$) increases by \$100 million. By contrast, a reserves sale of \$100 million has no effect on ($h_{AT} - h_{SDB}$), since the basis spread does not change, so it must induce the same decline in ($CA + g$) that is prompted by a forward sale.[8]

The Determination of Whether to Intervene in the Spot or Forward Market Depends on the Shock

Comparison of equations (5.11) and (5.12) in the annex shows that both commodity (ε_{CS}) and financial (ε_{FS}) shocks have the same effect on spot and forward rates in the model. Neither of them, therefore, affects the basis spread. However, a shock to hedging demand (ε_{HS}) has a greater effect on the forward rate than on the spot rate.

Economic considerations would, in general, preclude intervention to support the domestic currency in response to an adverse commodity shock, unless there

[8] It is assumed that changes in the central bank's forward position are analogous to changes in the spot reserves position, in that a change in the stock of reserves or forwards is assumed to be permanent. This implies that forward contracts are rolled over on expiration, absent further intervention.

are financial stability reasons to mitigate the shock. Otherwise, the model points to an intervention strategy of using either spot or forward intervention in response to a financial shock, and of favoring forward intervention in response to a hedging shock. A fourth potential shock (not represented in the model by an ε variable) would correspond to an increase or reduction in the marginal propensity to undertake synthetic dollar borrowing, γ_{SDB}, perhaps because of a structural change in onshore funding conditions. Here the model leads to a clear recommendation, as this term does not appear in equation (5.11)(which expresses the exogenous determinants of the exchange rate), but does appear in equation (5.12) for the forward intervention. The correct response to a change in this propensity would be forward rather than spot intervention.

EMPIRICAL RESULTS

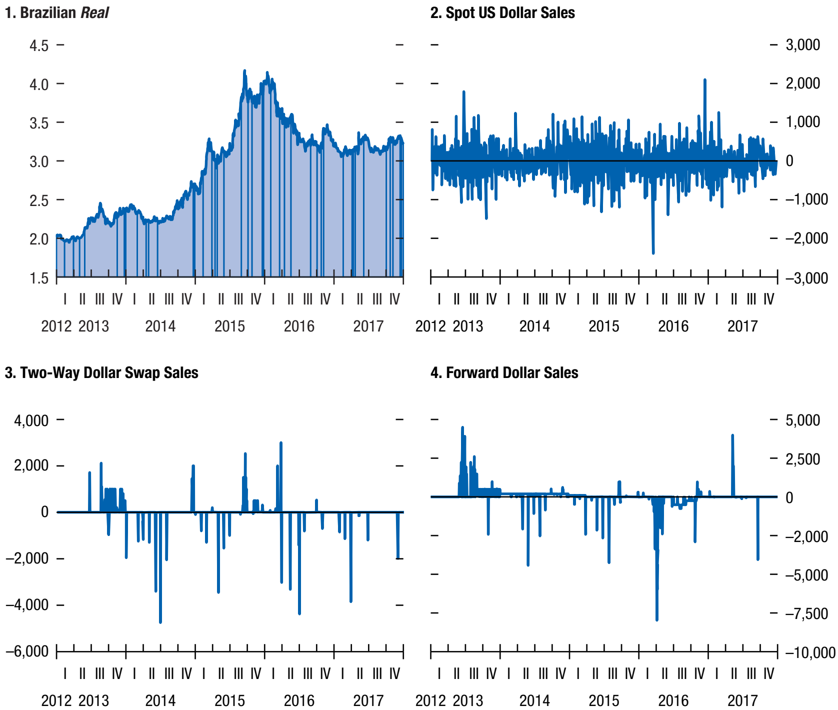
To gauge the empirical applicability of the model, tests were conducted using recent daily spot and forward intervention data from Brazil (Figure 5.3), Mexico (Figure 5.4), and Peru. Several factors tend to limit the empirical investigations of the effects of forward intervention. Until recently, few central banks have published data on forward interventions, particularly at a daily frequency. In addition, the exact form of forward operation varies considerably by country, as do the instruments used (such as nondeliverable forwards, options, swaps, futures, and so on). Tests of intervention in either the spot or forward market tend to be subject to high endogeneity—it is often difficult to separate the effects of the circumstances that prompted the intervention (such as capital flight) from the effects of the intervention itself.

One set of tests focuses on the model's conclusion that spot and forward operations have similar effects on the exchange rate. A second set examines whether there is an identifiable effect of forward intervention on basis spreads, as the model predicts. The sample period of 2013–17 for all three countries corresponds to a phase of capital outflows, particularly for Brazil, and for Mexico during the latter part of the period. Accordingly, intervention was generally aimed at supporting the domestic currency, although in Brazil it was also focused, at times, on affecting the implied onshore US dollar interest rate.

The tests offer stronger confirmation of the basis spread hypothesis than they do of the equivalence of spot and forward intervention. For Brazil and Mexico, forward intervention variables are correctly signed (Table 5.2). For Brazil, the sale of currency swaps is shown to affect the basis spread, within a 99 percent confidence interval, with the expected sign.[9] For Mexico, forward US dollar sales have a significant effect, within a 95 percent confidence interval and with the expected sign, on the basis spread. As forward interventions in Mexico did not begin until

[9] This corresponds to results obtained by Garcia and Volpon (2014), who note the differential impact of spot and forward intervention, and the effect of forward intervention in inducing capital inflows.

Figure 5.3. Brazil: Exchange Rate, Spot Dollar Sales, Swap Sales, and Forward Dollar Sales, by Quarter, 2012–17



Source: Central Bank of Brazil.

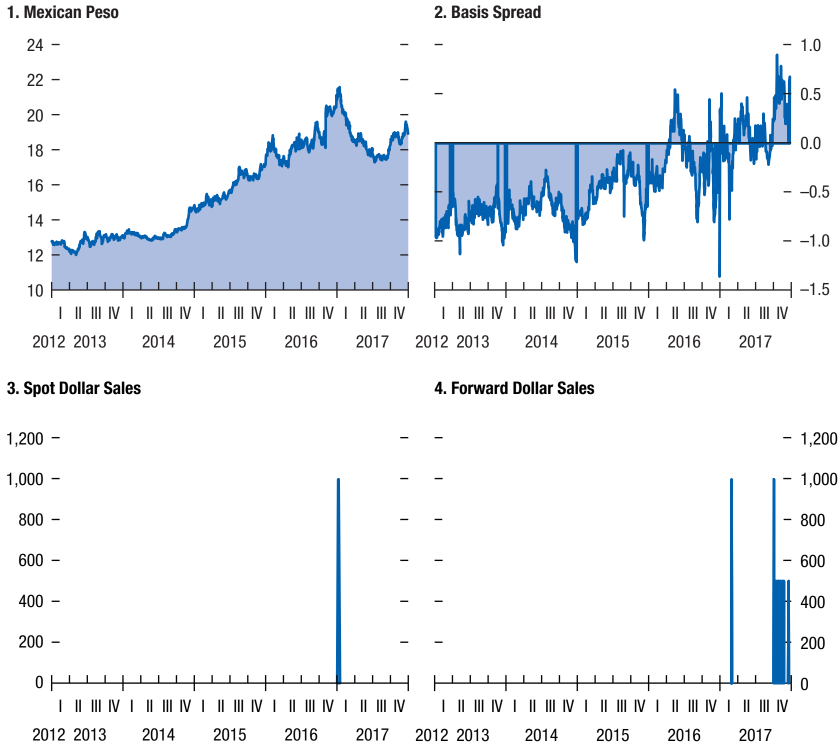
late 2016, this result reflects the experience of 2016–17. Tests for Peru do not show a significant effect of spot or forward sales on the basis spread.

The tests offer no more than very qualified support to the hypothesis that spot and forward interventions have equivalent effects on the exchange rate (Table 5.1). The case of Peru does support this hypothesis to some extent, in that the responses of the exchange rate to each type of intervention are similar. The regressions for Brazil and Mexico in this regard are inconclusive.

CONCLUSION

This chapter elucidates the features of forward intervention with a model that incorporates the motivations of different actors in forward markets. This model permits analysis of the potentially different effects of spot and forward intervention in currency markets. Key conclusions are that spot and forward intervention should have similar effects on the exchange rate, that forward interventions influence the basis spread, and that forward interventions are capable of inducing

Figure 5.4. Mexico: Exchange Rate, Basis Spread, Spot Dollar Sales, and Forward Dollar Sales, by Quarter, 2012–17



Source: Bank of Mexico.

capital flows, whereas spot interventions do not have this effect. The chapter offers data on when either spot or forward intervention is most appropriate, an area that can be expanded with future research.

Annex 5.1. Algebraic Manipulation of Equations (5.1) through (5.8)

The balance of payments condition, equation (5.7), can be rewritten as follows:

$$\Delta R = \alpha + (\delta_{OFF} - \delta_{SDB}) + (\varepsilon_{CS} + \varepsilon_{FS}) + (\beta + \gamma_g + \gamma_{AT} + \gamma_{SDB})e$$

$$+(\gamma_g + \gamma_{AT} + \gamma_{SDB})i - (\gamma_g + \gamma_{AT})\, i^* - (\gamma_{AT} + \gamma_{SDB})f \qquad (5.7')$$

Similarly, the forward-market equilibrium condition, equation (5.8), can be rewritten as follows:

$$\Delta W = (\gamma_{AT} + \gamma_{SDB})(-i - e + f) + \gamma_{AT} i^* + (\delta_{SDB} - \delta_{HD} - \varepsilon_{HD}) \qquad (5.8')$$

TABLE 5.1.

Spot Exchange Rate Regression

	Brazil	Mexico	Peru
Exchange rate, lagged	−0.07***	−0.02	0.06**
	(0.02)	(0.02)	(0.02)
Dollar sale	−0.000001	−0.000016	0.000006
	(1.80)	(0.000069)	(0.000004)
Dollar sale, lagged	−0.0000004	−0.002***	−0.0000034
	(0.000002)	(0.000070)	(0.000004)
Forward dollar sale	0.000002	−0.000005	0.0000024**"
	(0.000001)	(0.000044)	(0.000001)
Forward dollar sale, lagged	0.0000002	0.000012	0.0000009
	(0.000001)	(0.000043)	(0.000001)
Local currency swaps	0.0000007		
	(0.000002)		
Local currency swaps, lagged	−0.00000291*		
	(0.000002)		
Australian dollar spot exchange rate	−0.83***	−5.20***	−0.12**
	(0.18)	(0.66)	(0.05)
Colombian peso exchange rate	0.0002***	0.001***	0.00012***
	(0.00004)	(0.0001)	(0.00001)
Mexican peso exchange rate	0.05***		0.007**
	(0.01)		(0.002)
Peruvian sol exchange rate	0.28***	0.98***	
	(0.09)	(0.33)	
Turkish lira exchange rate	0.17***	1.51***	0.023
	(0.04)	(0.15)	(0.01)
Brazilian *real* exchange rate		0.89***	0.02***
		(0.10)	(0.01)
Euro exchange rate		−0.41	−0.0663
		(0.52)	(0.0430)
Japanese yen exchange rate		−0.01***	
		(0.004)	
Constant	0.000387	−0.00018	0.00013
	(0.001)	(0.003)	(0.0002)
R^2	0.31	0.45	0.24
Adjusted R^2	0.30	0.44	0.24
N	1163	1203	1193
F-statistic	44.0 (0.00)	81.27 (0.00)	35.52 (0.00)

Sources: Bloomberg, Finance L.P.; Central Bank of Brazil; Bank of Mexico; Central Reserve Bank of Peru; and author's calculations.
Note: The model implies that both spot and forward dollar sales should have negative effects on the exchange rate, of the same degree. All exchange rates are in units of local currency per US dollar. Spot and forward dollar sales and local currency swaps are in units of one million US dollars. All exchange rates are in first differences. Standard errors are in parentheses.
*p < .1; **p < .05; ***p < .01.

TABLE 5.2.

Basis Spread Regression

	Brazil	Mexico	Peru
Basis spread, lagged	−0.39***	−0.13***	−0.35***
	(0.02)	(0.03)	(0.03)
Spot exchange rate	−0.7	0.040**	0.57
	(0.72)	(0.02)	(2.70)
Spot exchange rate, lagged	−0.98	0.14***	9 2***
	(0.74)	(0.02)	(2.70)
Spot dollar sale	−0.0000011	0.00016***	0.0005
	(0.0001)	(0.0001)	(0.0004)
Spot dollar sale, lagged	0.000047	0.000082	0.0006
	(0.0001)	(0.0001)	(0.0004)
Forward dollar sale	−0.000027	0.000037	0.00016*
	(0.00004)	(0.00004)	(0.0001)
Forward dollar sale, lagged	−0.000021	−0.000071**	0.00021*
	(0.00004)	(0.00004)	(0.0001)
Local currency swaps	0.00019***		
	(0.00005)		
Australian dollar basis spread	0.04	0.01	0.08
	(0.12)	(0.01)	(0.10)
Australian dollar basis spread, lagged	0.033		
	(0.12)		
Colombian peso basis spread	0.049*		
	(0.03)		
Colombian peso basis spread, lagged	0.055**		
	(0.03)		
Peruvian sol basis spread		0.0003	
		(0.00250)	
Constant	0.001	−0.00028	−0.00017
	(0.02)	(0.0024)	(0.03)
R^2	0.17	0.07	0.13
Adjusted R^2	0.16	0.06	0.12
N	1035	1178	1167
F-statistic	16.23 (0.00)	10.17 (0.00)	19.69 (0.00)

Source: Bloomberg Finance L.P.; Central Bank of Brazil; Bank of Mexico; Central Reserve Bank of Peru; author's calculations.
Note: The model implies that a spot dollar sale should have no effect on the basis spread; a forward dollar sale should have a negative effect on the basis spread; and a sale of local currency swaps should have a positive effect. The dependent variable for each country is the per-unit change (first difference) in the basis spread. All independent variables are in the first difference form. Standard errors are in parentheses.
$^*p < .1$; $^{**}p < .05$; $^{***}p < .01$.

Solving the balance of payments condition, equation (5.7′), for the exchange rate e, yields the following:

$$e = \Omega^{-1}\Big[\Delta R - \alpha - (\delta_{OFF} - \delta_{SDB}) - (\varepsilon_{CS} + \varepsilon_{FS}) - (\gamma_g + \gamma_{AT} + \gamma_{SDB})i + (\gamma_g + \gamma_{AT})i^* + (\gamma_{AT} + \gamma_{SDB})f\Big], \tag{5.9}$$

where $\Omega = \beta + \gamma_g + \gamma_{SDB} + \gamma_{AT}$.

Similarly, solving the forward-market equilibrium condition, equation (5.8′), for f, yields the following:

$$f = \frac{1}{\gamma_{AT} + \gamma_{SDB}}\left[\Delta W - \delta_{SDB}\right] + i + e - \frac{\gamma_{AT}}{\gamma_{AT} + \gamma_{SDB}} i^* \tag{5.10}$$

Substituting equation (5.10) into (5.9) to eliminate forward rate f yields a solution for exchange rate e in terms of exogenous variables:

$$e = \frac{1}{\beta + \gamma_g}\left[\Delta R - \alpha - \delta_{OFF} - \left(\varepsilon_{CS} + \varepsilon_{FS}\right) + \left(\delta_{HD} + \varepsilon_{HS}\right) - \gamma_g\left(i - i^*\right) + \Delta W\right] \tag{5.11}$$

Conversely, substituting equation (5.9) into (5.10) results in an expression for f in terms of the exogenous variables:

$$\begin{aligned} f = \frac{1}{\beta + \gamma_g}\Bigg[& \frac{\Omega}{\gamma_{AT} + \gamma_{SDB}}\Delta W + \Delta R + \beta i - \frac{\gamma_{AT}\beta - \gamma_g \gamma_{SDB}}{\gamma_{AT} + \gamma_{SDB}} i^* \\ & - \frac{\beta + \gamma_g}{\gamma_{AT} + \gamma_{SDB}}\delta_{SDB} - \alpha + \frac{\Omega}{\gamma_{AT} + \gamma_{SDB}}\left(\delta_{HD} + \varepsilon_{HS}\right) - \delta_{OFF} - \left(\varepsilon_{CS} + \varepsilon_{FS}\right)\Bigg] \end{aligned} \tag{5.12}$$

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CHAPTER 6

Intervention under Inflation Targeting

Marcos Chamon, David Hofman, Nicolás E. Magud, Umang Rawat, and Alejandro Werner

This chapter takes a close look at the experience with intervention under inflation-targeting frameworks in Latin America. In particular, it discusses the challenges of combining foreign exchange intervention with the commitment to inflation targets, and how central banks in the region have dealt with that challenge. Further, the chapter compares the transparency and predictability in foreign exchange intervention with that of the standard monetary policy instrument (for example, the policy rate) for inflation targeting. Finally, the chapter investigates the extent to which buy and sell interventions have been symmetric, the costs of intervention, and its pros and cons in the presence of high financial dollarization. A key takeaway is that clear communication and transparency policies may have been instrumental in conveying the subordination of the intervention policy to the inflation objective, thus keeping inflation expectations anchored and building the credibility of central banks.

INTRODUCTION

The analysis in the book thus far has mostly skirted the relationship of foreign exchange interventions with the broader monetary policy framework, the topic of this chapter. The experience of several Latin American countries with decidedly hybrid policy frameworks—in which inflation targeting and (sometimes very frequent) foreign exchange interventions have now coexisted for a considerable period—is of broader interest and provides a rich source for study.

The chapter highlights specific tensions and trade-offs that inflation-targeting central banks face when they intervene, and it discusses how Latin American central banks have dealt with them. It concludes that monetary authorities appear to have successfully handled these tensions, helped by communication policies that managed public inflation expectations.

The views expressed in this chapter are those of the authors and should not be attributed to the IMF.

Challenges of Combining Intervention with Monetary Policy

An inflation-targeting central bank should, by construction, focus monetary policy on its inflation target and allow the exchange rate to float freely. In theory, its response to exchange rate movements should not go beyond the pass-through to inflation and inflation expectations (that is, second-round effects). But as documented in other chapters, Latin American inflation-targeting central banks have continued to care about, and indeed sought to influence, in some cases, developments in the exchange rate for reasons beyond its impact on inflation.

Figure 6.1 shows that the volumes of intervention have not been trivial in the region. As discussed in Chapter 2, the motivations for this are manifold. In particular, currency mismatches on borrowers' balance sheets—a key issue in several countries in the region—can lead to financial stability concerns, which are often within the central bank's mandate. Sharp movements in the exchange rate may also have nonlinear effects on inflation expectations, particularly if there are credibility concerns. That is, even if the pass-through is perceived to be relatively small, sharp movements may have confidence effects and lead to more agents changing their prices based on the exchange rate.

In practice, Latin American central banks have used foreign exchange intervention as the main instrument to achieve exchange rate objectives and address such concerns. Having this additional tool has given these central banks more options, and it may have improved overall policy outcomes. In particular, foreign exchange intervention has arguably helped mitigate the impact of shocks to the exchange rate, while allowing central banks to maintain the primacy of their inflation objective (along the lines argued in Ostry, Ghosh, and Chamon 2012). As such, the use of foreign exchange intervention may have created the space for central banks to focus interest rate policy squarely on inflation.

The use of foreign exchange intervention, however, involves considerable trade-offs. For one, its use could send mixed signals to the general public about the central bank's objectives and thereby undermine the credibility of its commitment to the inflation target. Generally, it appears that Latin American central banks have managed this potentially important tension well. Inflation expectations have mostly remained anchored at the target in Latin American countries, including for frequent interveners (such as Peru) or for those that experienced a temporary increase in size and frequency of intervention (such as Mexico in recent years) (Figure 6.2).[1,2]

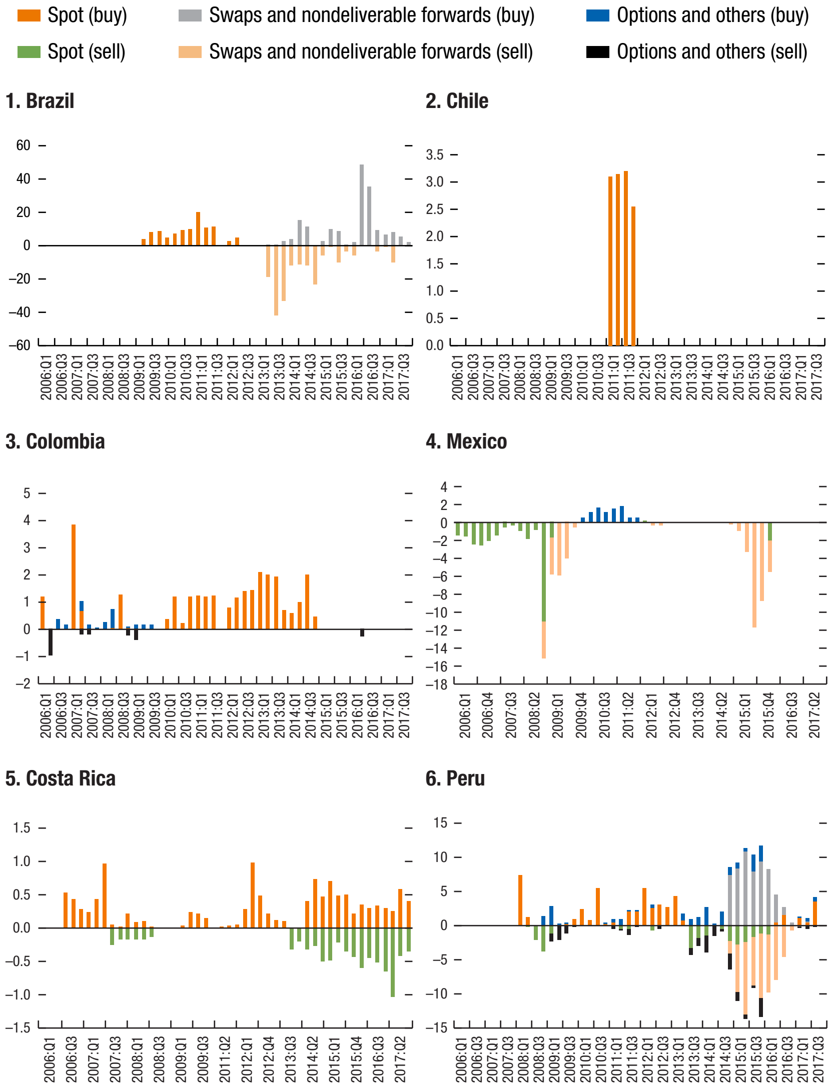
This has been, in part, supported by clear foreign exchange intervention communication strategies. Central banks in the region have published official communiques whenever they have put in place programs for purchasing international reserves or when they adjusted intervention rules. This information was readily

[1]Inflation expectations became unanchored in Brazil but for reasons that were unrelated to foreign exchange intervention.

[2]In Uruguay, however, inflation is more volatile and not as strongly anchored as in other countries. In part, this could be because Uruguay is the only country that stopped using inflation targeting when it moved back to monetary aggregate management in July 2013.

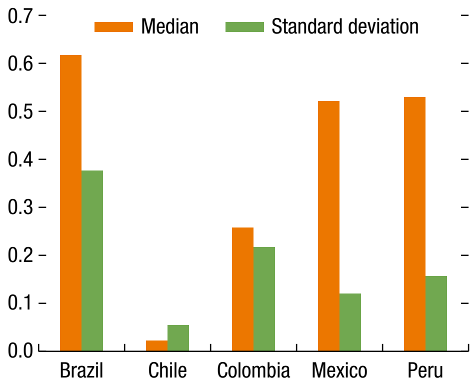
Figure 6.1. Foreign Exchange Intervention in Latin American Countries, by Instrument and Exchange Rate

(Billions of US dollars, left scale)



Sources: Central banks; and IMF staff.
Note: Data are by quarter for each year.

Figure 6.2. Annual Deviation of Inflation Expectations from Target, 2010–17
(Percentage points)



Sources: Central bank data; and IMF staff calculations.

available to the public, including on central bank websites. At the same time, when intervention was implemented, central bank authorities would spread the message by educating markets and the public as needed. In addition, even if intervention was discretionary, information and data disclosure policies have been very transparent (see Chapter 3). These communication efforts also contributed to an understanding that even when intervention was deemed necessary, central banks did not deviate from their commitment to price stability. This may have helped maintain the credibility of the central banks' inflation targets.

A possible trade-off also pertains to the interaction between exchange rate and inflation developments. A simple assignment of tools (policy rate for inflation; foreign exchange intervention for smoothing excess exchange rate volatility) may provide a framework to communicate policy and to analyze the trade-offs involved. But foreign exchange interventions will still have spillovers to monetary policy. Even if intervention is fully sterilized, any effects on the exchange rate will have implications for prices and domestic demand. When a central bank decides to intervene, the extent of the intervention and its traction therefore matters for the fine-tuning of monetary policy. For example, if foreign exchange sales significantly slow the pace of depreciation, they may shorten the monetary policy tightening cycle required to reduce inflationary pressures, and vice versa. And given the uncertainties about the effectiveness of intervention, fine-tuning this policy mix can be a considerable challenge. In principle, the impact of intervention on the exchange rate should be front-loaded (in the sense that intervention should affect the exchange rate on impact, and if anything, the effect will only become weaker over time). This attenuates the coordination problem, as the exchange rate would have adjusted by the time the policy rate needs to be fine-tuned again. In other words, intervention likely has a short transmission lag, which would facilitate coordination with other policies.[3] Conversely, however, the effect of intervention may be temporary (as some of the evidence presented in Chapter 4 suggests). Uncertainty over its persistence can complicate the decision of how to take foreign exchange interventions into account when setting the policy rate. Matters become even more complicated if the exchange rate response incorporates the market's expectation of future interventions by the central bank, as temporary effects fade.

Given the close interaction between exchange rate and inflation, some central banks elsewhere in the world have used exchange rates, at least partially, as an operating target to help achieve the inflation objective.[4] For instance, the Monetary Authority of Singapore uses the nominal exchange rate as the instrument of monetary policy. The exchange rate is sometimes also used as a temporary instrument when other transmission channels are impaired. For example, in 2013, the Czech National Bank used the exchange rate as an additional monetary policy instrument to fight deflationary pressures while at the zero lower bound. This latter case illustrates the use of the exchange rate as an instrument of monetary policy even in an inflation-targeting context. The Latin American central banks in this book, however, generally rely on the policy rate as their policy instrument and have not declared the exchange rate a formal operating target under their inflation-targeting strategies.

The literature and country experience provide limited guidance for deciding how to best integrate foreign exchange intervention into monetary policy decisions. But central banks arguably already face similar challenges in the absence of intervention. For example, whenever there is a shock to the exchange rate, central banks must choose whether they view it as persistent or transitory when deciding whether to adjust policy. While mistakes can be made on that assessment, opportunities often exist to adjust mid-course (for example, lengthening or shortening a monetary policy cycle as the shock proves more or less persistent). Central banks do not publish any hard numbers on the perceived effectiveness and persistence of their foreign exchange intervention. While they may have internal models to inform decisions, if the academic literature is any indication, that guidance is likely incomplete. This suggests there is a good amount of trial and error when implementing intervention policy.

[3]What makes monetary policy challenging is the long transmission lag for the policy rate to affect domestic demand and prices. If intervention had a similarly long transmission lag, combining the two policies would be even more challenging.

[4]Disinflation in several Latin American countries was carried out through "crawling peg" schemes. Once inflation stabilized at acceptable levels and inflation expectations were anchored, these countries moved to flexible exchange rates and eventually to a full-fledged inflation target, using the interest rate as the policy instrument.

Has the Response to Appreciation and Depreciation Pressures Been Symmetric?

Central banks facing excessive appreciation have typically responded by increasing international reserves accumulation—often trying to mitigate the negative impact of stronger currencies on competitiveness, owing to Dutch disease. A simple (perhaps simplistic) view is that the intervention response to appreciation and depreciation pressures should be symmetric, particularly for small shocks. But matters become more complicated in the face of large shocks. Countries can run out of reserves when they respond to depreciation pressures, while there is no upper bound on their reserve accumulation when responding to appreciation pressures. The cost of policy errors may also be asymmetric as overaccumulation of reserves may be easier to correct or accommodate than overdeployment. For example, if a central bank feels it has accumulated too many reserves, it can simply stop accumulating reserves until the stock of reserves comes in line with its precautionary needs, or it can gradually unwind some of these reserves (see Chapter 11 on Mexico). But an excessive loss of reserves can prove costlier, especially if the central bank is perceived ex post as having tried to maintain an unsustainable level of the exchange rate. These issues are particularly pertinent if the stock of reserves is relatively low, leaving the economy more vulnerable to external shocks.

In line with this intuition, countries have proved far more willing to accumulate reserves than to deploy them. Some examples include Brazil and Mexico. Brazil did engage in a large-scale intervention program through swaps. At the peak of that program, the stock of swaps (which settled in local currency) corresponded to about one-third of the stock of reserves. Mexico deployed about 10 percent of its reserves in 2015–16. The relative extent of foreign exchange sales was much smaller in other countries in the region. The observed asymmetry of interventions suggests that, in practice, intervention policies affect not only short-term volatility but can also affect the longer-term trend of exchange rates. This, in turn, has implications for monetary policy.

Costs of Intervention

The discussion so far abstracts from the pecuniary cost of intervention. As mentioned in Chapter 2, there is no consensus in the profession as to the exact nature of these costs. But several observers have focused on the differential between domestic and foreign interest rates as the cost of intervention. That metric has some drawbacks, however. For instance, it does not take into account the extent to which reserves reduce risk premia. Nonetheless, the interest differential can provide a useful first approximation of the cost. Normally the cost of holding reserves should not deter central banks from accumulating reserves until precautionary needs are met. Past that point, however, significant costs would warrant a close look at the marginal benefits of any further accumulation. Each percentage point of interest differential implies that the carrying cost of

10 percent of GDP worth of reserves is 0.1 percent of GDP. That is no small figure. And in practice, countries have much higher stocks of reserves and face much wider interest rate differentials. Costs can be amplified if reserve accumulation is a one-way street (that is, countries accumulate permanent reserves even in response to transitory shocks).

Transparency and Communication

The predictability of inflation-targeting central banks, when it comes to monetary policy, contrasts with the predictability of foreign exchange intervention. Inflation targeting implies having clear, transparent rules for the implementation of a central bank's monetary policy to anchor inflation expectations at the target. When it comes to foreign exchange intervention, we observed in other chapters that the region has an inclination for rules over discretion. Yet, we also document that rules are often updated, and that central banks switch from rules to discretion over time, and vice versa.

It is conceptually useful to compare the transparency embedded in anchoring inflation expectations under inflation targeting to that of foreign exchange intervention. One of the virtues of inflation-forecast targeting is that, based on the most recent and broad-based data available, interest rates are set to achieve the inflation forecast on the central bank's policy horizon. If no further shocks were to occur, the interest rate path would ensure that inflation would match the current inflation forecast. That is how anchoring of inflation expectations is achieved. Of course, unexpected shocks do happen. And central banks need to reflect these shocks in their future policy decisions to keep inflation expectations anchored in the inflation forecast at any future point in time. Transparency and effective communication are key in this process, including conveying to the market the relevant data used by the central bank to compute its inflation forecast. Latin American central banks provide this information, for the most part. This communication and transparency includes, among other things, monetary policy reports, data available on central banks' websites, expectation surveys, board member speeches, and so on. Monetary policy rates are adjusted in a fairly gradual manner. And markets have developed a sense of under which circumstances (and by how much) monetary policy could be adjusted following different shocks.

There is nothing remotely close to that framework when it comes to the communication of intervention policy. Even when intervention is rules-based, there tends to be frequent changes to the rules in response to exchange rate market developments. For example, Mexico increased the volume or lowered the trigger for its intervention rules in 2015, as depreciation pressures proved more persistent than originally anticipated. This contrasts with having an overarching contingent rule or framework in place that could accommodate a wide range of shocks and both appreciation and depreciation pressures as they materialize.

There are important differences between the inflationary process and the exchange rate. One major difference is that stabilizing inflation is *the* objective of monetary policy. As a result, we should not expect intervention, even when rules are clearly spelled out, to necessarily have the same stabilizing effect on the exchange rate as, say, a Taylor rule would have on inflation. Indeed, foreign exchange intervention, whether based on rules or discretion, appears not to anchor expectations for exchange rate volatility in the way that inflation expectations are anchored with inflation forecasts. In fact, it is not uncommon to observe spikes of market volatility or disorderly conditions even when there are rules dictating when and how much the central bank would intervene. It is worth stressing that this discussion does not factor in the operational secrecy discussed in Chapter 3—as opposed to the transparent operational mechanisms of monetary policy implementation.

Intervention by Latin American central banks is already among the most transparent. Further improvements in communication could help financial markets better internalize the reaction function of the central bank to sharp and unstable movements in exchange rates. The more this internalization occurs, the less likely that actual intervention will be necessary. This then matters in mitigating excessive intervention—closing a virtuous cycle of anchoring exchange rate volatility expectations; that is, disorderly market conditions may be prevented by the expectation of intervention through clearly communicated rules should those conditions arise, thereby reducing the need for actual intervention. If so, and to the extent that such anchoring does not prevent needed adjustments in the level of the exchange rate, in response to structural shocks, this could also help keep inflation stable. Thus, it contributes to achieving central banks' inflation targets.

Interventions and Currency Mismatches

As discussed in Chapter 2, the presence of significant currency mismatches or dollarization can raise financial stability risks associated with exchange rate volatility. They are therefore often cited as a motivating factor for foreign exchange interventions. Banks in highly dollarized countries often lend in foreign currency to borrowers with little or no foreign exchange earnings. This does not eliminate the currency risk, which is just transferred to the borrower. In fact, it transforms it into a higher credit risk, since the borrower would struggle to repay in the event of a significant exchange rate depreciation. In such circumstances, depreciation can increase the amount of nonperforming loans and potentially induce a financial crisis. In addition, banks' dependence on foreign currency liabilities (as core funding decreases) can put pressure on international reserves when central bank liquidity support is needed. If currency mismatches are widespread, therefore, interventions to smooth exchange rate adjustments can help ease the pressures related to short-term fluctuations by providing borrowers with a window on which to hedge their balance sheet risks and reduce currency mismatches. Arguably, by reducing sharp, short-term movements in the exchange rate, interventions may also help prevent panics and self-fulfilling runs on foreign currency.

At the same time, however, intervention can provide adverse incentives for economic agents and facilitate, or even encourage, currency mismatches. As mentioned in Chapter 2, large foreign exchange reserves may encourage risky liability structures; for example, as borrowers taking on short-term external debt count on the central bank to provide foreign exchange liquidity if they were to face tighter global financial conditions (Kim 2008). The volatility of inflation relative to that of change in the real exchange rate is an important determining factor for the degree of financial dollarization. Residents hold a larger share of their portfolio in foreign currency assets as inflation becomes relatively more volatile and as the real exchange rate becomes more stable (Ize and Levy-Yeyati 2003). Thus an exchange rate that can move freely in both directions makes foreign exchange risk more apparent and introduces a disincentive to financial dollarization. According to Rennhack and Nozaki (2006), allowing greater exchange rate flexibility and refraining from seeking an undervalued currency discourages financial dollarization. Similarly, Hardy and Pazarbasioglu (2006) show that greater two-way exchange rate flexibility may deter foreign currency deposits, as they increase the risk of holding foreign currency assets.

Among the countries examined in this book, dollarization continues to be an issue mainly for Costa Rica, Peru, and Uruguay (Box 6.1). In part because of this structural vulnerability, Peru intervenes more frequently than many of its peers. While these interventions have helped smooth exchange rate volatility in Peru, by limiting upside exchange rate risks, and may thus have helped stave off financial stability risks, it is also possible that they have incentivized continued dollarization or contributed to a slower de-dollarization.

CONCLUSION

The experience of Latin American central banks with foreign exchange intervention under inflation-targeting frameworks has been instructive. While there can be inherent tensions between the effective pursuit of exchange rate objectives alongside an inflation target, Latin American central banks, on balance, appear to have managed these tensions with considerable success. Clear communication policies appear to have played a key role. Indeed, these may have been instrumental in maintaining the primacy of the inflation objective and facilitating a relatively firm anchoring of inflation expectations as the inflation-targeting frameworks gained credibility. Moreover, a transparent and well-communicated foreign exchange policy appears to have helped the market internalize the central bank's reaction function. It also contributed to understanding that these interventions were subordinated to the interest rate policy aimed at anchoring inflation expectations. The Latin American experience thus suggests that this internalization can enhance the effectiveness of intervention and inflation stabilization more generally, while helping improve the credibility and effectiveness of the central bank.

Box 6.1. Dollarization in Latin America

Latin America has countries with persistently high dollarization as well as countries that have avoided financial dollarization altogether.

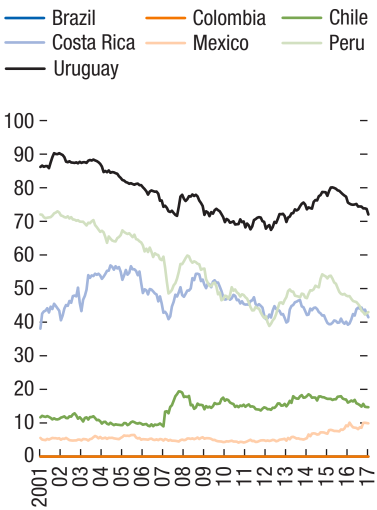
During 1990–2001, dollarization rose markedly in several countries, including Bolivia, Costa Rica, the Dominican Republic, Honduras, Nicaragua, Paraguay, Peru, and Uruguay (Rennhack and Nozaki 2006). Thereafter, some of these countries—in particular, Bolivia, Paraguay, and Peru more recently—have managed to achieve a significant reduction in dollarization.

Most of the countries that are part of our study in this book, such as Brazil, Chile, Colombia, and Mexico, have avoided significant dollarization (Figures 6.1.1 and 6.1.2), despite experiencing severe macroeconomic problems in the 1980s. The availability of indexed financial instruments helped prevent dollarization in the cases of Brazil and Chile (despite the former experiencing a hyperinflation). In other countries, however, such as Peru, the public responded by switching away from the domestic currency toward dollars. Today, dollarization remains high in Peru despite more than two decades of prudent macroeconomic management, albeit with a declining trend.

While dollarization continues to be an issue in selected economies only, even countries that never experienced domestic dollarization still experienced significant currency mismatches on the liability side as governments, banks, and firms accessed international financial markets in the 1990s, thus accumulating foreign debt. These mismatches contributed to currency crises in Mexico in 1995 and in Brazil in 1999.

Figure 6.1.1. Deposit Dollarization, 2001–17

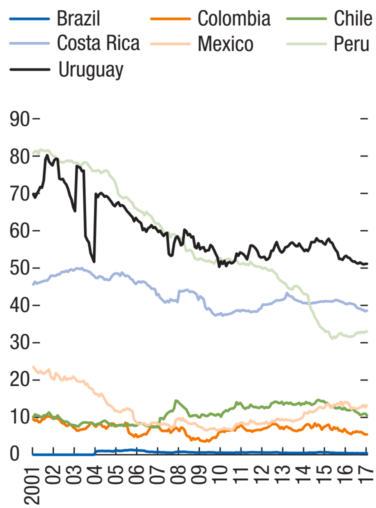
(Ratio of foreign currency deposits to total bank deposits, percent)



Source: IMF staff calculations.
Note: Data are from December of each year.

Figure 6.1.2. Loan Dollarization, 2001–17

(Ratio of foreign currency deposits to total loans, percent)



Source: IMF staff calculations.
Note: Data are from December of each year.

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PART II

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CHAPTER 7

Brazil: Taking Stock of the Past Couple of Decades

João Barata R. B. Barroso

This chapter describes the exchange rate regimes, possible policy rationales, and public operational guidelines for foreign exchange intervention in Brazil over the past couple of decades. Based on an assessment of intervention effectiveness, it proposes a flowchart that approximates the decision-making process and that may guide policymakers facing similar conditions. Historical records show that a managed floating regime often emerges in response to high levels of volatility in global liquidity. International reserve accumulation is the natural response to periods of high global liquidity and a good backing for interventions in periods of high volatility. Brazilian authorities have favored rules-based and preannounced strategies with swap interventions to address hedging demand, and spot or repo interventions to address liquidity pressures. They use discretion regarding the timing of the interventions and the corresponding announcements.

INTRODUCTION

Foreign exchange intervention in Brazil is not for beginners.[1] The exchange rate regime has been a managed float since the demise of the crawling peg in the late 1990s, but with evolving perceptions about the desirability of intervention and the pecking order of different intervention policies.

There is wide consensus that international reserve accumulation has served the country well, but there is also an ongoing debate about the level of reserves and its relation to different deployment strategies. Intervention policies during past crises have covered the spectrum of spot, credit, and futures market operations, all targeted and calibrated to very specific concerns of policymakers. While these policies tend to be discretionary regarding the timing of large intervention programs, their inclination has been for rules-based approaches that preclude signaling a preference for specific exchange rate levels, accompanied by a carefully designed communication strategy to avoid bad equilibrium outcomes. There are certainly many lessons to

The opinions expressed in this chapter are the sole responsibility of the author and are not necessarily those of the Central Bank of Brazil.

[1] This line borrows from Tom Jobin, a Brazilian composer, who once said, "Brazil is not for beginners."

learn from their systematic study of the strategies and results in the past couple of decades.

The views presented in this chapter build heavily on commentary by the policymakers responsible for designing intervention policies over the years (Franco 2000; Fraga 2000; Bevilaqua and Azevedo 2005; Mesquita and Torós 2010). They also build on academic and policy work that explores a range of issues related to capital flows, exchange rates, and official interventions (Barroso 2011, 2014, 2017; Barroso, Pereira da Silva, and Sales 2016).

Given that the information is well documented by these and other sources, the picture that emerges from the exercise is panoramic in nature. By approaching a large set of regimes and intervention episodes, the similarities and basic rationale guiding policy decisions should become clear—this is probably the value added from this chapter relative to others in the literature. Another distinct advantage of the chapter is the cautious, normative motivation. The goal here is not only to summarize facts and opinions but also to extract useful evidence-based policy recommendations.[2]

The first challenge is to present the main features of the exchange rate regimes and associated intervention policies adopted over the past couple of decades. Linking the regime with the intervention results in a richer descriptive classification than the traditional de facto approaches offered in Ilzetzki, Reinhart, and Rogoff (2017). The analysis begins with the crawling peg of the 1990s and then moves along the managed float regimes that persist to this day. The rich experience with intervention policy implies that there are many significant subperiods to explore. The second section below takes some time to introduce the main features, rationale, and likely effectiveness of the intervention policies adopted in each of the exchange rate regimes.

The first years of floating offered a rare opportunity for experimentation, with progressive free floating giving way to managed floating on the back of a sequence of crises. These crises allowed policymakers to conduct a reality check, so to speak, of their preconceptions regarding the floating regime, and it set the basis for the intervention strategy in the subsequent years. The lessons of such a reality check are summarized in the third section of the chapter. They point to the need for accumulating international reserves in proportion to foreign liabilities—an effective leaning-against-the-wind strategy that hedges aggregate risk, reducing the incidence and severity of crises, and essential to efficient global safety net design.

There are noticeable regularities in the operation of intervention policy during the managed float period, which are also explored in the third section of this chapter. The timing of intervention follows global liquidity conditions, with good times stimulating reserve accumulation, and bad times leading to the official provision of foreign currency liquidity by the central bank. Policymakers define the size of interventions with transaction-level information on currency markets.

[2] Of course, the future may be sufficiently different from the past to render these conclusions useless; with this caveat, it seems a good idea to rationalize past decisions in search of guidance for the future.

The communication strategy favors the preannouncement of the size of derivative interventions to buy time and to smooth balance sheet adjustment. It also favors unlimited interventions in spot and credit markets for as long as necessary. The effectiveness of intervention policy is explored in the fourth section of the text. The effect of intervention on the level and volatility of the exchange rate has the expected sign, according to the academic literature that explores instrumental variable or event study methodologies.

The fourth section of the chapter also presents a flowchart summarizing the decisions behind intervention policy in Brazil. It has both a descriptive dimension, as it fits the historical experience, and a normative dimension, as a blueprint for future policy. This flowchart will help policymakers from other jurisdictions to appreciate the Brazilian foreign exchange framework, and to see the wisdom of such a framework.

EXCHANGE RATE REGIMES

A panoramic view of exchange rate regimes in Brazil since the 1990s shows a trend toward a managed float with a large stock of international reserves—although not without experimentation around pegs and free-floating approaches. De facto classification systems, as in Ilzetzki, Reinhart, and Rogoff (2017), capture the broad boundaries of regimes but are probably too coarse to capture the rich experience in the country. It is particularly challenging to capture the different models during the managed-float period, especially during the 2000s.

Table 7.1 classifies recent experience, with a listing of the different periods, the de-facto regime, the economic context, and the broad lines of the intervention rationale. The text that follows offers supporting evidence for the classification. Figure 7.1 helps to gauge exchange rate dynamics in different periods; it is in real terms, so there is no trend associated with different levels of inflation (which is positive for Brazil). An important disclaimer is in order: To keep the focus on exchange rate regimes, this section pays only cursory attention to other aspects of the economic and political context.

From 1994 to 1999, the exchange rate regime in Brazil converged to a crawling peg after initial attempts with free floating. Indeed, the early 1990s in Brazil began with the "Real Plan," the stabilization plan that famously ended hyperinflation in the country. As with many similar programs in emerging and developing economies at the time, the exchange rate peg was at the heart of the strategy. The creative twist was the phase-in of the peg with a unit-of-account-only currency, before actually issuing the sovereign currency. Another twist was that the new currency was actually allowed to float freely in its first few months of existence, which led to considerable appreciation.

After a good start, 1994–98 saw a succession of emerging market crises (the Tequila crisis in 1994, the Asian crisis in 1997, and the Russian crisis in 1998) that put a lot of pressure on the exchange rate. Policymakers chose to adopt a

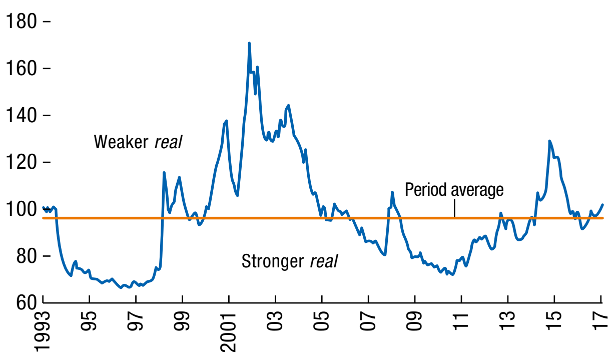
TABLE 7.1.

De Facto Exchange Rate Regimes in Brazil, 1994–2017

Period	Regime (De Facto)	Context	Intervention
1994–99	Crawling peg	Real plan	Monetary policy rationale
1999	Free falling	Currency crisis	Too costly to peg
1999–2001	Managed float	Inflation targeting	Tried rules-based intervention
2002	Free falling	Political uncertainty	Too costly to manage
2003–08	Managed float + reserves accumulation	Inflation targeting with international reserves	External adjustment + global liquidity = prudent to accumulate
2008	Managed float + crisis intervention	Dollar liquidity crisis in spot, future, and credit	Intervention in all markets followed by low interest rates
2009–12	Managed float + reserve accumulation	Quantitative easing in advanced economies	Excessive credit + US dollar liquidity = prudent to accumulate
2013–16	Managed float + swap program	Taper tantrum, first hike, China, commodity glut	Official hedging supply rules-based intervention
2016–17	Managed float + swap program reversed	Normalization, benign interregnum	Prudent to rebuild buffer, rules-based accumulation

Source: Author.

Figure 7.1. Real Effective Exchange Rate in Brazil, 1993–2017
(Index, June 1994 = 100)



Source: Central Bank of Brazil.

crawling peg in order to accommodate some of the pressure without severe domestic or external adjustments.[3]

Indeed, as the pressure on the peg mounted, the government entered an IMF program to defend it. In spite of the program, the continuing deterioration of the economy and costly necessary adjustments eventually led the government to abandon the peg in January 1999. The country then entered a free-falling exchange rate regime—per the terminology of Ilzetzki, Reinhart, and Rogoff (2017). The issuance of US dollar–linked government debt during the peg period smoothed the effect on private balance sheets, and thereby on economic activity, a lesson well taken for the future. While devising a new nominal anchor strategy that could accommodate a floating exchange rate, the central bank relied strongly on large interest rate differentials.[4] In July 1999, after the renegotiation of the IMF program to accommodate the new policy framework, the government established the inflation-targeting regime with a floating exchange rate.[5]

From the establishment of inflation targeting in 1999 up to 2001, the exchange rate regime was that of managed floating. Within the spectrum of floating exchange rate regimes, it is fair to say that policymakers preferred free floating to managed floating during the first years of inflation targeting. In fact, exchange rate volatility was actually quite low at first, and little intervention was deemed necessary. Nevertheless, history has a tendency to repeat itself. Once again, after a good start, there was a succession of crises (Argentina's default in 2001, the US terrorist attack in 2001, and Brazil's election in 2002) that put great pressure on the currency. During the first two crises, policymakers offered foreign exchange hedges as the main intervention policy. By the end of 2001, the central bank had issued US dollar–linked securities that came close to $20 billion. In 2002, it announced a derivative contracts program to the same effect (the "swap contract" offers the exchange rate variation plus an onshore US dollar interest rate for the domestic interbank rate). Central bank–issued notes and swaps were substitutes for scarce reserves.[6]

Later in 2002, during the electoral campaign, convertibility risk became a primary concern to market participants: first, because of allegedly risky positions on foreign debt attributed to the election frontrunner, and second, because the public sector was a net debtor in foreign currency, which led to negative feedback between depreciation and the fiscal position. The rules-based swap program was not sufficient anymore, and discretionary spot interventions were the second line of defense. As seen in Figure 7.1, the high costs of defending the currency eventually led to a free-falling regime that endured until the postelection policy framework became clearer and the default risks were dissipated.

[3] See Franco (2000) for a firsthand account and the next section for the economic rationale for minimizing exchange rate volatility in general.

[4] See Fraga (2000) for a firsthand account of the brave few months of free floating.

[5] See Carvalho and Vilela (2015) for a counterfactual evaluation of the costs associated with maintaining the peg versus implementing the inflation-targeting regime with floating.

[6] See Bevilaqua and Azevedo (2005) for an overview of the period by policymakers.

After the election, beginning in 2003, the new government acted aggressively to build credibility. A strong external sector adjustment made possible the initial accumulation of nonborrowed international reserves. At the same time, the central bank announced that it would no longer roll over 100 percent of its US dollar notes and swap contracts. It retired $9 billion of securities in 2003 and $26 billion in 2004. Global liquidity conditions in great part determined the pace of retirement, with discretion exercised in the rollover rate. By 2004, international reserve accumulation was an official policy and the net foreign creditor position an explicit goal for the economy. By 2006, the central bank began to issue reverse swaps to cope with one-sided appreciation bets in the futures market and to build a contrarian position to be unwound when conditions turned. The new policies meant frequent interventions in the spot and futures markets. The rules-based intervention for the spot market strove not to signal any preferred level for the exchange rate (as detailed in the next section). As shown in Figure 7.1, in spite of systematic intervention, the exchange rate strongly appreciated from 2003 to 2008. With international reserves increasing from under $50 billion to over $200 billion, the period is classified as a managed float with international reserve accumulation.

The payoff from the strategy became clear during the global financial crisis. The exchange rate depreciation experienced after September 2008 was much more "controlled" than the ones experienced in free-falling episodes of the recent past. The regime could be classified as a managed float with crisis intervention. Indeed, the accumulated buffer in the futures market allowed the central bank to offer ample hedge at low cost, while accumulated reserves allowed it to offer spot dollars to address a relatively small repatriation demand and to substitute for thin international trade finance. Instead of increasing the interest rate, as in the past crisis episodes, the central bank was able to reduce interest rates as soon as the US dollar markets normalized.[7,8]

An important aspect behind the success of intervention policies during the global financial crisis is that, with the international reserve accumulation policy and retirement of public foreign debt instruments, the country had become a net creditor in foreign currency. Therefore, the initial exchange rate depreciation strengthened the external position and increased the credibility of the intervention policy.

By the end of 2009, the central bank had already zeroed its position in future and credit markets and resumed the accumulation policy. From 2009 to 2012, quantitative easing in the United States was an important driver of capital inflow to emerging markets. Barroso (2017) estimates that around 50 percent of capital inflows to emerging markets was caused by quantitative easing by the US Federal Reserve—from $50 billion to $80 billion in the case of Brazil. The decision to

[7] Monetary policy also waited for interbank market normalization obtained by the reduction of reserve requirements. See Barroso, Gonzalez, and Doornik (2016) for a review and evaluation.

[8] See Mesquita and Torós (2010) for the official view from policymakers.

steepen the accumulation of international reserves in that period was associated with an abundance of global liquidity. Reserves increased from around $200 billion to $350 billion, and the regime was once again a managed float with reserve accumulation.

Faced with high global liquidity and apparently improving balance sheets, the financial and nonfinancial private sectors tapped international capital markets. Policymakers offered some moderation with a mixture of interest rate policy, macroprudential policy, capital flow management, and leaning against the wind. Barroso, Pereira da Silva, and Sales (2016) show that quantitative easing boosted economic activity, credit markets, and asset prices—accounting for the full feedback of these factors on each other, and accounting for the endogenous policy responses in terms of macroprudential policy, monetary policy, and international reserve accumulation. In retrospect, it was hard to strike a balance, even though policymakers seemed confident. The taper tantrum in 2013 put this conviction to a test.

With the end of quantitative easing getting closer, and after announcements to that effect, it became increasingly clear that Brazil had overstretched its foreign borrowing and built external imbalances—despite the countervailing policies adopted in the previous period. Facing a potential "rush to the door," policymakers adopted the time-honored decision to offer swap contracts to help private participants orderly hedge and retire exposures. This was the beginning of the managed-floating-with-swap-intervention program. In August 2013 the Central Bank of Brazil announced daily sales of $500 million in swap contracts until the end of the year. It extended the program in December of the same year and again in mid-2014—in response to deteriorating external conditions on the back of financial stress in China and hesitating moves by the US Federal Reserve.

By March 2015, the central bank had accumulated swap exposures of $108 billion. Based on the estimates of the quantitative easing-induced capital inflows to Brazil in previous years, it seems the program was more than adequate. With the political turbulence the country would face in the coming years (for example, an impeachment of the president), it proved wise to have had a large program. A crucial difference with analogous programs from the early 2000s is that international reserves now offered a hedge to the central bank, which minimized concerns with convertibility risks and contingent fiscal liabilities. Instead of the free-falling regimes of the past, it allowed for a controlled adjustment of the exchange rate (see the following section on the effectiveness of interventions).

With the worst of the political turbulence in the past, and given the onset of a benign external environment and the continuation of macroeconomic adjustment (in external balances, private balance sheets, and interest rates), some exchange rate appreciation was in order. Even though there had been no speculation of convertibility risk in the immediate past, the onshore US dollar interest rate and market commentary did provide warning signs during peak political turbulence. Policymakers took notice and turned their attention to the concept of international reserves net of the swap position. With this mindset, and assuming the benign external environment was temporary, the central bank began issuing large amounts of reverse swaps to reduce its net swap position—even if implying a slightly slower convergence of inflation to the target. By the end of 2017, with a pause in the second semester of 2016 to reassess the benign external environment, the central bank had reduced its swap position to $24 billion. This is referred to in Table 7.1 as "managed float + swap program reversed." In both the swap and reverse swap periods, there was no further accumulation of international reserves.

It is interesting that after all the swings in the exchange rate and exchange rate regimes of the past couple of decades, at the end of 2017 the real exchange rate was back to the point where it began in 1994.

INTERVENTION STRATEGIES AND RATIONALE

Reality Check from the First Years of Floating

The good initial performance of the floating exchange rate appeared to corroborate a more benign view of free floating.[9] In admittedly simplistic terms, this view is summarized with three propositions: First, the exchange rate mostly reflects fundamentals, although with short-run overshooting a la Dornbusch. Second, depreciation stimulates the economy with foreign demand and is a first line of defense in a crisis. Third, liquidity problems are rare and can be handled within the multilateral safety net system. The next years of the floating regime saw the reemergence of crises and exchange rate volatility, and the ensuing reality check and slow convergence toward a new consensus with a more nuanced view on exchange rate flexibility.

This is the first reality check of the period: Leaning against the wind might be a good policy after all, since volatility and persistent trends are disconnected from fundamentals and from efficient allocations. There is hardly any controversy in the statement that the exchange rate should reflect fundamentals. In principle, this allows it to function as an effective shock absorber and to give correct signals to private agents and policymakers. The problem is that floating exchange rates are much more volatile than fundamentals (Obstfeld and Rogoff 2000). Evans (2012) shows that interest rate differentials cannot explain exchange rate variance for either short or long horizons.

The literature often relies on risk-sharing shocks or uncovered interest parity shocks, sometimes reverse engineered into a preference shock, to account for the stylized facts, but the debate is still open. In principle, if no clearly identified fundamental shocks drive the exchange rate volatility, it seems unreasonable to suppose such volatility would support efficient allocations. In reality, it leads to risk premiums that likely distort allocations across sectors and time and affect the

[9] This is, in part, because of the small pass-through of the large initial depreciation. Burstein, Eichenbaum, and Rebelo (2005) show that this results from the fact that nontradable goods demand does not respond strongly to depreciation in emerging markets, and therefore does not pressure wages, and that it is costly to unilaterally reset prices.

transmission of shocks to inflation through synchronized price setting. The persistence of the shock is also a concern. It is reasonable to expect (and consistent with empirical evidence) that long appreciation trends are followed by sharp depreciations, as it is difficult to shift resources to a previously shrinking tradable sector (Caballero and Lorenzoni 2007).

Stepping back a moment, it is not even clear if depreciation is a net positive for economic activity, in all cases, through its effect on the foreign demand channel. For emerging markets, the common incidence of external credit constraints and private sector reliance on foreign currency debt have wide-ranging implications. Large depreciations interact negatively with foreign currency debt, which leads to a reduction of external credit lines and market access. The resulting reductions in domestic demand might be larger than the increase in foreign demand. This is the case in a relevant class of models (Jeanne and Korinek 2010), where the reduction in domestic demand falls more heavily on nontradables and further depreciates the currency, which creates a negative feedback loop.

This is the second reality check of the period: It seems important to offer a hedge or outright liquidity to the private sector to minimize the negative financial accelerator mechanism associated with depreciations. If convertibility is not an issue, which is the case when large international reserves are available, the hedge seems to be a good first line of defense. The argument depends on assuming that tapping foreign capital markets and allowing private balance sheets to have exposure to the risk will yield welfare gains. It also depends on the foreign exchange markets being sufficiently underdeveloped to raise significantly the incidence of one-sided markets.[10]

For the multilateral system to work, crises must be sufficiently infrequent and nonsynchronized. The emerging market crisis of the 1990s and the global financial crisis warrant some caution in this regard. In parallel to new injections of resources at the multilateral level, international reserve accumulation accelerated in emerging markets. Barroso (2011) documents that crisis episodes in Latin America, broadly defined, are less frequent, although in a nonlinear way, in the presence of a large ratio of reserves to foreign liabilities. That is the third reality check: Besides smoothing the severity of a crisis, international reserves reduce the incidence of crises and are therefore key ingredients of the global safety net. As already pointed out, emerging market crises are essentially balance sheet crises. The ratio of large international reserves to external liabilities could, in principle, minimize such risks.

There we have the main elements of the "new consensus" emerging out of the first years of floating. The central bank should lean against the wind in the exchange rate market to improve allocative efficiency and to accumulate reserves in the case of appreciation trends. It should be ready to offer hedge and liquidity to private participants in the case of one-sided markets. International reserves

[10] The Brazilian foreign exchange market is deep and liquid, but arguably underdeveloped, in part due to low levels of foreign asset holdings by domestic private investors with long horizons.

should be commensurable with external debt to reduce crisis severity and incidence, complementing the global financial safety net. The next sections detail the intervention strategy adopted in subsequent years and the rationale for the operational framework.

International Reserve Accumulation Policy

Interventions in the spot market in Brazil from 2004 to 2012, excluding interventions in 2008 because of the global financial crisis, have followed an official policy of international reserves accumulation. In fact, this was a de facto rather than official policy until the global financial crisis, after which it conspicuously appeared in official speeches and documents. For example, in the first edition of the "International Reserve Management Report," published in June 2009, the central bank states that the increase in reserves is the "result of the reserve accumulation policy started in 2004." The motivation for the policy (as explained in the previous section), was to build a sufficiently large buffer to the economy while leaning against appreciation trends. The policy has an operational framework, which covers daily intervention strategy, timing, rationale, and tentative reserve adequacy metrics. As for the timing, it is associated with a set of indicators, including appreciation trends, capital inflows, and growth in foreign debt liabilities that occur in the context of global liquidity—such as the ones prevalent in the two major periods of international reserve accumulation.

The basic operational guideline is that the central bank should "buy net order flow." This is a rules-based definition of the size of daily interventions. As explored in the foreign exchange market microstructure literature (Evans and Lyons 2002; Vitale 2007), net order flow is the main proximate driver of exchange rate dynamics. The rationale for this result is that interdealer trade based on private customer order flow reveals the aggregate order flow to the market, and this public information is fully priced by the market at the end of the day. If the central bank buys from dealers based on central bank observations of aggregate order flow, it affects interdealer trade but conveys no additional information to the market. The same result follows if the central bank buys order flow less than proportionally or up to an error. This flexibility is relevant for the actual operation of daily interventions, given its interaction with onshore dollar liquidity.

Onshore interest rates tend to respond to dollar liquidity. As a result, systematically buying in excess of order flow tends to attract even more order flow. To avoid these negative feedback dynamics, the operational rule could react less than proportionally to the order flow and include a random component to the decision. This operational rule is a good description of actual interventions during accumulation episodes.[11] The rule reduces the effectiveness of the leaning-against-the-wind policy and the pace of accumulation (see below for the link between the size of the

[11] The regression coefficient of weekly interventions on weekly order flow from 2007 to 2013, in periods of positive spot interventions, is around 0.26, which explains 32 percent of the variation in interventions.

intervention and the effect on the exchange rate). In addition, the proportion between intervention and order flow might be modulated in the presence of policy trade-offs, such as appreciation trends that help control inflation through their effect on tradable goods, while still offering some support to activity through favorable investment conditions.

The central bank communicated its rules-based intervention strategy to convey that it was not targeting any specific level for the exchange rate or any specific target for the rate of change of the exchange rate. "Buy net order flow" is a clever compromise between leaning against the wind and the floating regime.

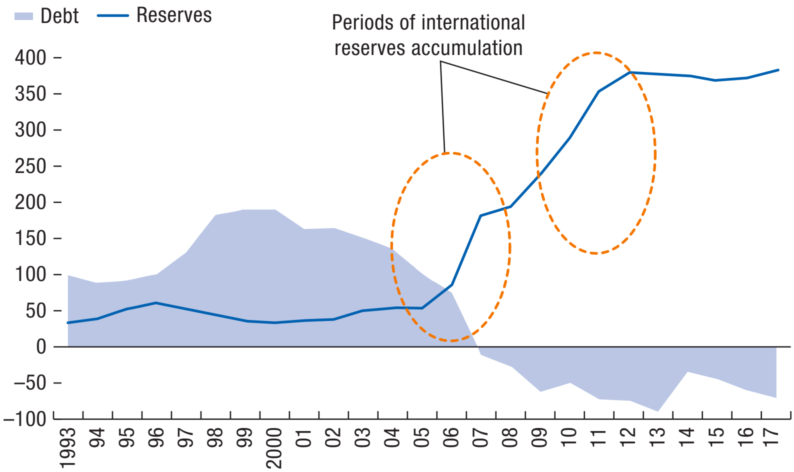
The implementation of the "buy net order flow" rule relies on the central bank having an informational advantage in the spot market. This is the case in Brazil, where policymakers have complete information on the net order flow, based on the electronic records of private transactions reported by financial institutions. Each participating institution in the over-the-counter spot market collects partial information through its own order flow, but not the aggregate total. As a result, even though the central bank is following a rules-based approach, market participants cannot anticipate the size of the intervention on any single day and must incorporate these transactions in the interdealer market.

There is no official reserve adequacy metric. However, the reality check from the initial years of floating made clear the importance of the reserves to foreign debt ratio. The excess of debt relative to reserves prompts negative feedback loops in depreciation episodes. As seen in Figure 7.2, from 2004 to 2008, intervention raised international reserves to the same order of magnitude as the sum of public and private debt. This was presented sufficiently many times in official central bank communication to make it a plausible de facto adequacy metric. Other metrics, such as the ratio to short-term debt or imports, were also mentioned with some frequency, but reserves were much larger than what would be indicated by such metrics. During the second accumulation period, from 2009 to 2012, reserves increased almost in tandem with external debt, so again the ratio looked like a good adequacy metric candidate, although with a large safety margin. To the extent that it signaled a fully developed hedging market, domestic institutional investors' holdings of foreign assets could be another factor to be considered in the future.[12]

One missing piece of the argument is the cost of holding international reserves. In a rare public assessment by Central Bank of Brazil staff, based on precautionary models, Silva (2011) discusses a range of scenarios for international reserves cost and the expected output loss during a crisis and finds that if a crisis occurred only once every decade or so, the avoided losses would compensate the cost. Such exercises are viewed with skepticism in policy circles, where self insurance is not usually seen as the exclusive rationale for accumulating reserves. For

[12] As of June 2018, the ratio of domestic and foreign cross holdings of equities, debt, and credit was 12, 6, and 9 percent, respectively, which relates to the relevance of international reserves to this day.

Figure 7.2. International Reserves and Net Public and Private Debt, 1993–2017
(Billions of US dollars)



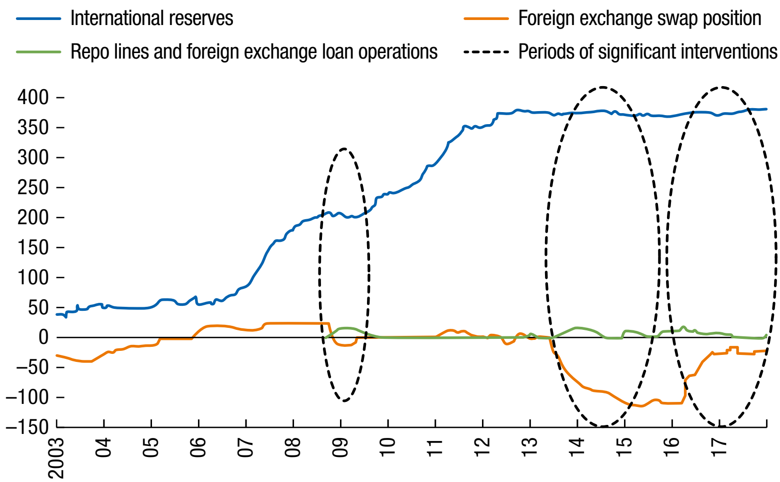
Sources: Central Bank of Brazil; and author.

example, it is often mentioned in international policy circles that reserves might have a role in reducing external credit constraints, improving financial stability, or stabilizing net foreign asset positions. It is also mentioned that reserves might be at whatever level results from leaning-against-the-wind policies of the past, given the reputational cost of reducing them afterward. Even in the context of very simple models that are based on self insurance, one must recognize that there is a high level of uncertainty regarding the effect of international reserves on crisis incidence and severity. High uncertainty aversion typically means that holding excessive reserves is much better than holding just the exact amount of reserves.

Intervention during the Global Financial Crisis

The global financial crisis was very much a US dollar liquidity crisis. During the crisis, the Central Bank of Brazil effectively acted as a foreign currency liquidity provider of last resort in spot, credit, and futures markets. The spot market US dollar shortage came from foreign investors' demand to repatriate funds. The credit market shortage came from exporters that lost credit lines abroad. The futures market shortage came from exporters that "overhedged" during the past appreciation trend, as well as from private participants, including banks, who had to roll over short-term hedges of medium- or long-term US dollar liabilities. The interventions were successful, judging by the normalization of US dollar liquidity captured, for example, by the spread between onshore and offshore US dollar interest rates (in January 2009, these measures were back to the levels of August 2008). Interventions were also short-lived in comparison with the protracted

Figure 7.3. International Reserves, Swap Position, and Repo Position, 2003–17
(Billions of US dollars)



Source: Central Bank of Brazil; and author.

consequences of the crisis in global financial markets. They also benefited from the extraordinary swap arrangements by the US Federal Reserve on a global scale.

Communication was a key element of the policies. The Central Bank of Brazil preannounced a ceiling to the entire volume of swap interventions to reassure private participants, and it announced it would offer as many US dollars as necessary in the spot and credit markets. Stone, Walker, and Yasui (2009) provide an interesting empirical assessment of the effects of interventions by the central bank during the financial crisis in 2008. In general, announcements are found to have a greater impact on the level of the exchange rate than the interventions themselves. This result signals two things: First, there was sufficient central bank credibility; and second, there were sufficient reserves to support the claims. Another communication strategy was that the central bank continued to report its trade credit assets as qualified international reserves.

Calibrating the size of the interventions captured in Figure 7.3 was key to their success. For the spot market, the central bank had complete information from the order flow, disaggregated to the transaction level, and so could make a good diagnosis of the source of the liquidity demand. The bank also had good estimates of the net international liability position at a disaggregated level, particularly the debt instruments. The data indicated that repatriation was manageable, given that the central bank would also reduce hedging costs with swap interventions. In total, the central bank sold $14.5 billion in spot auctions, or 7 percent of precrisis reserves.

The central bank also had full information on trade credit operations down to the transaction level, which is not large in Brazil, relative to the size of the economy, and there is a stable relationship between trade credit and trade activity. Based on this assessment, authorities committed to offer as much US dollar credit as necessary, until credit markets resumed normal operations. In total, the central bank loaned $24.5 billion in repo auctions, or 12 percent of precrisis reserves.

As already noted, preannouncing a high ceiling for swap operations was essential to the intervention communication strategy. The central bank has access to registers at the central derivative clearing of the country, which provide a good basis for estimating the total hedging needs. Matching this with debt information registered with the central bank, one has a good idea of the rollover needs, in case there is a mismatch in maturity of debt and hedges. The coarse granularity of the market, with enough big players and public comprehensive balance sheet information, also helped in the assessment. Informed by this exercise, the $50 billion initial ceiling looked like a sufficiently high number. Considering actual interventions, the central bank sold $33.0 billion in swap auctions, or 16 percent of precrisis reserves, which gives a rough estimate of the spot market pressure one would face without swap intervention. Because the swap is a nondeliverable forward contract with domestic currency settlement, there was essentially no pressure on international reserves.

It is worth commenting on the interaction of foreign exchange intervention policy and monetary policy during the crisis. As noted, for the first time Brazil was able to use countercyclical monetary policy during a crisis. However, the monetary easing did not come immediately after the crisis. The strategy at the time, communicated by central bank authorities, was first to normalize the transmission channels and then begin monetary policy normalization. Accordingly, the central bank first announced its intervention package, including foreign exchange intervention, and then made sure the liquidity squeeze subsided before beginning a new easing cycle. In this context of the global financial crisis, it is fair to assume that an aggressive easing would interact adversely with the US dollar liquidity crisis.

The Swap Program after the Taper Tantrum

The liquidity squeeze in spot and futures US dollar markets was not as large as during the crisis, but private balance sheets were more fragile. The main concern was accumulated foreign debt from the quantitative easing period. There was a lot of anxiety in global markets with policy normalization. From the taper tantrum in May 2013 to liftoff in December 2015, and the second hike in federal funds in November 2016, the normalization process advanced by a sequence of bold moves intercalated with setbacks and financial turbulence. The motivation for the intervention policy was to avoid panic and allow rational calculations to dominate the adjustment of debt profiles and foreign currency exposures. Spot interventions could have the opposite effect and induce market participants to liquidate positions as soon as possible. Swap interventions create conditions for adjustment, and by the nature of nondeliverable forwards, preserve international reserves for use in case of panic.

The key communication strategy to obtain such an effect is to preannounce a "sufficiently large" intervention. Unlike the crisis intervention that set a total ceiling and left some freedom for daily operations, this time around, both the total amount and the daily interventions were set in advance (see the previous section for the exact timing and content of the announcements). The very strict rules-based intervention was designed, in part, to avoid signaling any preference for the level of the exchange rate.

To set the size of the swap intervention, policymakers must consider a large number relative to foreign liabilities, based on the consolidated information from the central bank and central clearings datasets. The level of corporate sector debt in the country around the tapering of quantitative easing was close to the average emerging market, just below 50 percent of GDP, with 65 percent in local currency versus 35 percent in foreign currency. Of the 35 percent in foreign currency, 12 percent referred to exporters, 6 percent to nonexporters with local hedge, 5 percent to nonexporters without local hedge but with foreign headquarters, 5 percent to nonexporters without local hedge but with foreign assets, and 6 percent to unhedged exposure. This last part alone totaled $70 billion; and there were residual unhedged positions in all debt categories. It is difficult, however, to distinguish what is the normal level of risk taking from what is excessive and therefore susceptible to instability. One alternative is to estimate what the debt levels would have been without quantitative easing. Estimates known to policymakers at the time point to a figure of the same order of magnitude as unhedged plus some imperfectly unhedged positions (Barroso 2017; Barroso, Pereira da Silva, and Sales 2016). By this metric, it was clear that conditions warranted a sizable intervention.

However, large interventions are not without their problems. First, lower cost of hedging could induce more debt-taking abroad to build arbitrage positions, which is self-defeating, for the stated purpose of the policy. Second, market participants must believe there will be no convertibility problems in the future to keep hedging positions with nondeliverable forwards, so that a large enough swap position might lead the market to self-fulfilling concerns with convertibility, and again the policy is self-defeating. Garcia and Volpon (2014) provide an insightful discussion of the problems, which only increased with the accumulation of swaps in the balance sheet of the central bank. At some point, market participants began focusing on international reserves net of swaps, which was probably an early sign that the intervention was reaching its limit. Policymakers recognized these issues. In particular, the link between swap interventions and US dollar liquidity was clear enough to lead policymakers to conduct regular repo line auctions, either as a feature of the program or conditionally on the onshore US dollar rate (an indicator of liquidity demand).

The policy would start to be reversed once domestic political volatility reduced, and global liquidity conditions improved—at first by discretionary rollovers and then by the auction of reverse swaps to imprint a fast-paced reduction of the swap position. There was no official statement on the goal of reducing swaps to zero, and so there was considerable flexibility in the conduct of the intervention policy. Official communication depicted this movement as an accumulation of "international reserves net of swaps." It seems this last concept conveys accurately the size of the buffer available to cope with a crisis.

ASSESSING INTERVENTION POLICY

Intervention Effect on the Exchange Rate

The reality check from the first years of floating maintains that leaning against the wind is a sensible strategy. However, this requires sterilized intervention (or swap intervention) to have an actual effect on the exchange rate, which is a controversial proposition. Empirically, it is usually difficult to estimate the effect of intervention due to the simultaneity problem. If the central bank sells foreign currency when the domestic currency depreciates, a naive empiricist might say it caused the depreciation. Indeed, this is the sign of the correlation and the sign of coefficients in ordinary regressions. The traditional econometric solution to get the right causal effect is to find an instrumental variable, that is, a random variable related to the depreciation only through its impact on the central bank. The literature uses instrumental variables related to news, market expectations, and the reaction function of the central bank with mixed results (Dominguez and Frankel 1993; Galati, Melick, and Micu 2005; Kearns and Rigobon 2002; Tapia and Tokman 2004).

For the case of Brazil, one may highlight the results from Barroso (2014), who adopted a method that is both general and distinct from the literature. It begins by showing that realized volatility (that is, the intraday sample volatility) fits the formal requirements of an instrumental variable by pure deductive reasoning. A large class of models makes realized volatility depend on volatility—such as offered in Hansen, Huang, and Shek (2011). Simple algebra then shows lagged realized volatility is orthogonal to the innovations. The correlation with intervention policy is ensured by central bank behavior, which at least in Brazil, is usually cautious with exchange rate volatility. The method allows weighted estimation, which proved to be an important feature. If the endogeneity problem is particularly severe in high volatility periods, with the intervention failing to completely reverse foreign exchange shocks, then it makes sense to reduce their weight.

Across several specifications, including the nonparametric instrumental variable, results are similar. The average effect of a $1 billion sell or buy intervention is a depreciation or appreciation of around 0.50 percent, respectively. In the alternative specification that includes swap interventions as a control, the estimate for spot is a bit lower (0.30 percent), which suggests intervention policies are complementary. In this alternative specification, the effects from swap operations are around 0.25 percent, with the correct sign, but are not statistically significant in the sample (2007–11). This last result might be related to the preannouncement of an intervention ceiling during the global financial crisis, which tends to generate some effects on impact and to confound the effect of ensuing swap auctions. All the results in this paragraph are weighted estimators, which are generally deemed more reasonable by central bank staff in foreign exchange desks and familiar with the method.

Several papers investigate the effects of spot interventions on the level of the *real* against the US dollar using different methodologies. Wu (2010) studies spot interventions with a structural vector autoregression motivated on microstructure models. Kohlscheen and Andrade (2013) study swap interventions with an event study method using intraday data and a dozen events. It is interesting that both studies look into high-frequency and microstructure features as solutions to the simultaneity problem, not unlike the realized volatility approach emphasized here. Although instrumental variable identification is not generally better, it is less demanding on the identifying assumptions. In the case of realized volatility, the assumptions are actually algebraic necessities, which make them particularly attractive.

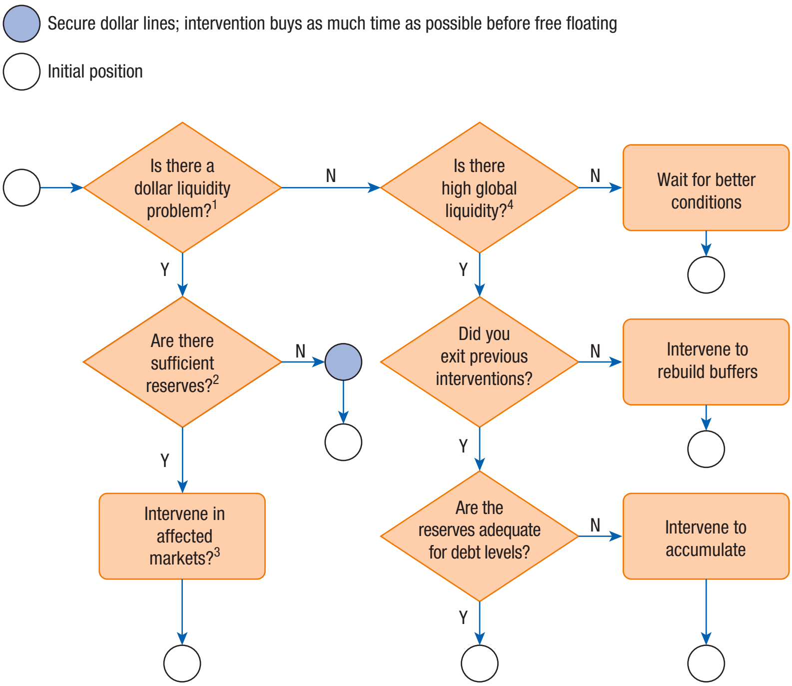
Assessing the effects of swap interventions is potentially more complicated than spot interventions. This is because of the preannouncement of such policies. The announcement of a new program is usually unexpected, while its implementation is predictable.[13] The interventions from 2013–16 are particularly hard to assess, because daily interventions were essentially deterministic. The appropriate methodology for this case is to build an empirical counterfactual and compare it to the actual exchange rate behavior. For example, the event study method assesses abnormal behavior in this manner. Chamon, Garcia, and Souza (2017) use a synthetic control approach that assumes exchange rates from peers provide a good basis to build a counterfactual for the Brazilian exchange rate without swap operations. The method assumes stability of the correlation with peers, which might not be the case when the market is reassessing relative fragilities. Other than that, it seems like a sound empirical strategy. Their results point to significant exchange rate effects only in the first swap announcement. Nevertheless, one must consider that the stated purpose of the intervention was not to lean against the wind of the exchange rate, but rather to smooth the effect of external turbulence on private balance sheets.

A Flowchart of Intervention Strategies

At the risk of oversimplification, this section attempts to compress the received wisdom from the past couple of decades into a simple flowchart (Figure 7.4). The figure represents a feedback system, so that after running through the decisions, one goes back to the initial position, represented by the open circle. It would be naive to expect that by following this exercise, another central bank could replicate the performance of the Brazilian experience. There is considerable judgment in every branch of the decision tree and considerable reliance on specific features of the domestic markets and the domestic surveillance system.

[13] Historically, the exit of the policies has also been less predictable, and hence, amenable to the instrumental variable approach.

Figure 7.4. Flowchart of Intervention Policy, Based on the Brazilian Experience



Source: Author.

[1] A dollar liquidity problem implies a one-sided market for spot dollar, dollar hedge, or dollar credit.
[2] To determine whether the reserves are sufficient, estimate the demand size with data from central clearings, order flow, and market participants.
[3] After estimating the size of hedging demand, one should preannounce swap interventions up to this size and implement spot and repo interventions as required to reduce onshore dollar rates.
[4] Also factor in trade-offs with business or credit cycles.

The first diamond of the flowchart poses a question about global liquidity. In case of US dollar liquidity problems (as captured by the monitoring of gross order flow and market prices), one should enter in a liquidity smoothing mode. Liquidity is broadly understood to capture spot, future, and credit market pressures. If there are sufficient international reserves for massive intervention (as assessed per the available information from granular debt, derivative, and order flow data at the transaction level), it should be undertaken. Unless there are signs of spot market liquidity pressures (typically high onshore US dollar rates) or convertibility concerns, swap interventions should be the main policy instrument. If reserves do not appear to be sufficient, external credit lines and swap agreements should be called, along with swap and eventual spot interventions, to buy time, but the economy should be ready for free floating in volatile conditions.

In case of abundant US dollar liquidity, one should take the opportunity to exit as much as possible from previous swap interventions. If reserves are less than adequate (typically assessed by its proportion to foreign currency debt of the private sector, which is ideally close to but higher than unity), policymakers should take the opportunity to accumulate liquid US dollar assets. The pace of interventions should consider trade-offs with monetary policy, particularly if appreciation is desirable from that perspective. As in every other step in the decision process, this too requires subjective input from policymakers.

In terms of governance, the authority for intervention policy decision-making lies with the board, with strong leadership from the governor and the deputy governor who have a mandate to oversee market operations, including monetary policy and foreign exchange operations. During periods with acute liquidity problems, other members of the board get closely involved as well. Other than that, the decision-making process of the board is fluid and case-specific. It is not clear whether a more richly detailed flowchart of intervention policy will be warranted in the future.

CONCLUSION

This chapter explores exchange rate regimes, policy rationales, and operational guidelines for foreign exchange intervention in Brazil over the past couple of decades.

The chapter culminates with an assessment of intervention effectiveness that includes a flowchart that approximates the decision-making process and guides policymakers in implementing exchange rate policy. As such, it has the received wisdom from the Brazilian experience. Policymakers from other jurisdictions should view these lessons with the understanding that they rely on specific features of Brazilian financial markets—such as the large nondeliverable forward and the low level of participation of domestic institutional investors in foreign asset markets and domestic hedging markets.

Much of this wisdom is the result of experimentation in the face of wildly shifting global liquidity conditions, international crises, and domestic uncertainty. The managed float solution emerges almost as a necessity to cope with the high levels of volatility and an inflation-targeting regime. The main lesson from the experimentation is that accumulating international reserves in amounts commensurate to foreign debt liabilities and keeping an otherwise stable macro-environment is a good strategy. It allows leaning against the wind when fragilities are being accumulated, smoothing the adjustment of private balance sheets during less tranquil periods, and reducing crisis frequency and severity. The operational guidelines favor rules-based and preannounced intervention as much as possible, to both preclude signaling central bank preferences on the exchange rate level and reassure markets of normal liquidity conditions going forward. In terms of instruments, swaps address a demand for hedging before it transforms into a demand for liquidity, while direct spot market intervention addresses liquidity pressures. It also preserves sufficient discretion in the timing of intervention programs, which minimizes possible moral hazard concerns and fosters risk-sharing with market participants.

Based on history, the framework is likely to evolve in the next couple of decades, once policymakers and the international community discuss and implement novel solutions and conceptual frameworks to deal with global volatility. It is not yet clear if domestic reforms will inspire large institutional investors with considerable investment abroad to hedge external debt in periods of short dollar liquidity. Nor is it clear how the now-frequent arrangements among groups of countries to share international reserves will evolve in the future. Coupled with the requirement that part of the reserve sharing has to be linked to lending programs by international organizations, it is clear that multilateral arrangements continue to be important. At the same time, several jurisdictions have accumulated large amounts of international reserves and have gathered evidence of their effectiveness in reducing exchange rate volatility.

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CHAPTER 8

Interventions in Chile

Catalina Larraín and Diego Saravia

In this chapter, we study the four episodes of foreign exchange interventions since the inflation-targeting regime was adopted in Chile, and we present the reasons and the communication strategy that the Central Bank of Chile followed. We ran event studies with day and intraday data to assess the effects of the announcements and actual interventions on the exchange rate level, trend, and volatility. The results suggest that announcements have clearer and more significant effects than the actual interventions. For the announcements, the results in level and trend of the exchange rate go in the expected direction and are bigger in the purchases programs than in the sales programs.

INTRODUCTION

Before Chile adopted a full-fledged inflation-targeting regime, in September 1999, its government had tried several exchange rate regimes: flexible, fixed, crawling pegs, and multiple exchange rates. Since 1999, the country has had a flexible exchange regime that, alongside a healthy financial system and responsible macroeconomic policies, is a pillar of inflation targeting. In this context, foreign exchange interventions have been remarkable exceptions—indeed, there were only four of them.

This chapter analyzes what motivated these interventions and their effectiveness; it describes the strategy of the Central Bank of Chile and reveals how it communicated that strategy to the market. To evaluate the drivers of intervention, the analysis relies on the official communiqués of the Central Bank of Chile; and to evaluate the effectiveness, it conducts event studies using daily and intraday data.

The evidence indicates that the announcements themselves, rather than the actual interventions, had an effect. The announcements had short-run effects on the nominal exchange rate and its trend, and that went in the expected direction. The four announcements and the actual sales interventions also tended to increase the volatility of the nominal exchange rate in the few days after the announcement of intervention.

The next section analyzes foreign exchange policies in the 1990s as background on Chile's move toward inflation targeting. The chapter then describes the four interventions in Chile since 1999 and conducts event study regressions

The opinions expressed in this chapter are the sole responsibility of the authors and are not necessarily those of the Central Bank of Chile.

to assess their effectiveness. Central bank communications strategy follows, and the final sections summarize the main lessons and conclusions.

THE ROAD TO INFLATION TARGETING

After decades of experimenting with fixed and multiple exchange rates, as well as crawling pegs, the Central Bank of Chile abandoned the exchange rate as a policy goal in 1999, which left the inflation rate as the only target. Describing in detail the exchange rate regimes before the adoption of the inflation target (and exchange rate flexibility) goes beyond the scope of this chapter. But some exchange rate background of the 1980s and 1990s provides the context in which this adoption took place.

Chile was hit by a financial and banking crisis in 1982 that required the abandonment of the fixed exchange rate adopted in 1979. The economic policy objective in the remaining years of the 1980s was to reconstruct the financial system, which demanded bailouts of the private sector from the central bank and the government. In this context, inflation averaged 20 percent until the end of the decade, and the exchange rate followed a crawling peg to avoid significant real currency appreciation.

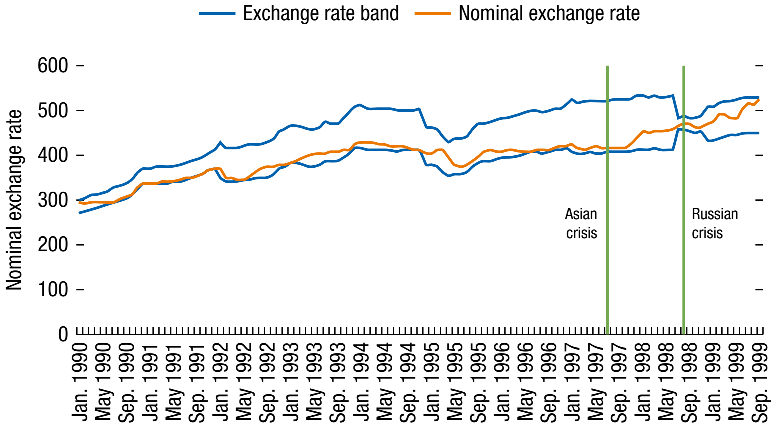
In 1989, the Central Bank of Chile became autonomous, and it has used two policy targets since then. First, the exchange rate was allowed to fluctuate within a defined band, and second, an inflation target was announced yearly in September (until 1998). Chile's inflation was gradually reduced from 23 percent at the beginning of the decade to 3.2 percent in late 1999.

In the early 1990s, amid capital inflows, the Chilean peso appreciated. As Figure 8.1 shows, the nominal exchange rate was often at the lower bound of the target band, and the monetary authority continuously widened the band in response, changed the central parity, and intervened in the foreign exchange market. These actions, and the fact that inflation remained near the target in those years, are anecdotal evidence that the inflation target prevailed over the exchange rate whenever they came into conflict.

During the Asian crisis in 1997, pressure to appreciate the local currency vanished, and depreciation pressures were met with foreign exchange interventions and tight monetary policy. Despite depreciation after the Asian crisis, the exchange rate was still at the lower bound of its band in early 1998. The central bank feared that the sharp depreciation of the peso threatened the inflation target set for that year, so it intervened in the foreign exchange market and raised its benchmark interest rate.

In June 1998, the exchange rate was still in the lower part of the band, despite a 10.8 percent depreciation since October 1997. The central bank decided to narrow the band—from 12.5 percent above and below the center, to 3 percent above and 2.5 percent below the center—to curb depreciation expectations. At the same time, the central bank confirmed its commitment to the inflation target for the end of the year. The central bank coped with a narrower band and the external

Figure 8.1. Exchange Rate Band, 1990–99
(Chilean pesos per US dollar, observed Central Bank of Chile)



Source: Central Bank of Chile.

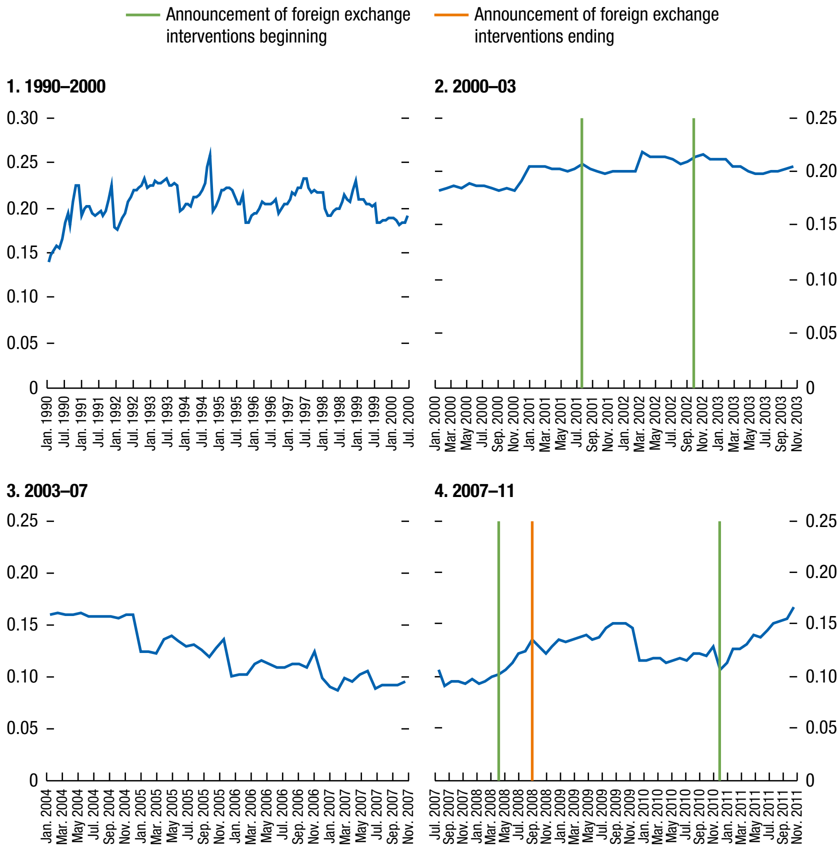
shock coming from the Russian financial crisis (which increased the cost of borrowing and reduced Chilean terms of trade), using an increase in interest rates, which exacerbated the contractionary effect of the foreign shock. It became more difficult to remain inside the band, and the central bank decided to widen it again to 7 percent (total width) and to continue widening it in subsequent months. The tightening of monetary policy was then gradually relaxed in the following months, because the economy was entering a recession, and no inflationary pressures were coming from peso depreciation.

In September 1999, when uncertainty declined, the central bank announced the end of the exchange rate band and adopted an inflation-targeting regime. During the exchange rate band regime, the central bank intervened whenever it deemed it necessary, without any notice.

The foreign exchange interventions implied an increase in foreign reserves until late 1997, and it reached its maximum value in October of that year. In June 1998, after narrowing the band, the national currency was depreciated, and the central bank sold reserves to keep the exchange rate within the band. These interventions lasted until September 1999, when the band regime was ended. Figure 8.2 presents the reserves-to-GDP ratio, which fluctuated around 20 percent during the 1990s, since both international reserves and GDP grew during that decade.

During the last period of the bands (1998–99), as the Chilean economy was recovering, and the central bank widened the band, interventions became less frequent and were concentrated between January 1998 and March 1999. Total foreign currency sold by the central bank reached $4.83 billion during 43 days of intervention (equivalent to 10 percent of the days of this period). The daily

Figure 8.2. Monthly Reserves over Yearly GDP, 1990–2011
(Reserves/GDP)



Source: Central Bank of Chile.

average amount sold was \$109 million in 1998, and \$39 million in 1999. These amounts varied considerably, with small interventions of \$5 million and larger, to above \$350 million. Also, the central bank did intervene with central bank dollar-denominated bonds (BCDs), when its sales concentrated between July 1998 and April 1999, and reached \$1,440 million on 60 different days (Morandé and Tapia 2002).

On reaching full inflation targeting, the monetary authority announced annual inflation targets in September of each year, until 1998. In September 1999, the central bank announced the annual target for the following year, along with an indefinite target that ranged from 2 percent to 4 percent starting in 2001.[1] Since then, keeping inflation at its target has been the sole commitment of the central bank.

The inflation-targeting regime adopted free flotation for the exchange rate and a comprehensive communication strategy to enhance policy transparency and credibility. Since April 2001, the main policy instrument has been the short-term nominal interest rate, and the target has been to keep inflation between 2 percent and 4 percent on a 12–24 month horizon. As the central bank recognized in its release of September 1999, a floating currency should give the central bank more autonomy to manage monetary policy and to increase its capacity to deal with external shocks. Since then, the Central Bank of Chile has been strongly committed to exchange rate flexibility and to the inflation-targeting regime.

Nevertheless, including in its announcement of September 1999, the central bank explicitly stated that it reserved the option to intervene in the foreign exchange market, but only in exceptional and qualified cases, and that it would report such decisions. In that communiqué, the central bank stated that it would provide biweekly (but with some delay) disaggregated information on the holdings of international reserves.

FOREIGN EXCHANGE INTERVENTIONS SINCE THE ADOPTION OF INFLATION TARGETING

During inflation targeting, inflation expectations have been anchored around the target most of the time, and foreign exchange interventions have been exceptional episodes.

As noted, since September 1999 the central bank has intervened only four times: in 2001, 2002–03, 2008, and 2011. In 2001 and 2002–03, it intervened to provide foreign currency liquidity (by selling US dollars and dollar-denominated bonds) as a result of overreactions in the foreign exchange market, mainly because of instabilities in neighboring countries. In 2008 and early 2011, the central bank announced foreign exchange programs to increase the availability of international liquidity (by purchases of US dollars).

Details of the four interventions are discussed in the next few pages.

First Intervention: August 16, 2001

From January to the beginning of August 2001, the currency depreciated a cumulative 20 percent—from Ch$574 to Ch$689, per dollar—in part because of the situation in Argentina and then exacerbated by the events of 9/11 in the United States. The central bank intervened, and its communiqué stated that “the complex financial situations experienced by some economies in the region [...] have caused instability in financial markets. This has been manifested in the exchange

[1] Board announcements can be found at http://www.bcentral.cl/en/web/guest/notas-de-prensa.

rate, without affecting, however, the perception of risk of the rest of the world on the Chilean economy [...] the succession of movements in the same direction have exacerbated the depreciation and volatility of the peso, concerning financial markets."[2]

The intervention program consisted of selling foreign currency in the spot market and increasing the sales of BCDs. The communiqué only specified the maximum amount of sales, stating that sales could occur up to $2 billion for the spot market and up to the same amount for the US dollar-denominated debt.

Spot market interventions totaled $803 million, less than half the maximum announced, and 5.2 percent of the stock of foreign reserves in December. Instead, the total sales of BCD reached $2.58 billion, from August 16 to the end of 2001.[3]

Second Intervention: October 10, 2002

The exchange rate depreciated 5.2 percent in September 2002, but with no major deterioration in its fundamentals, except for commotion from Brazil around the presidential elections of 2002. In the communiqué, the central bank stated that "during the last weeks, there has been an additional deterioration in the financial situation faced by some economies in the region [...] the depreciation of the exchange rate in recent months is the expected reaction [...] However, part of the recently observed depreciation reflects movements in a market that has operated with low liquidity and high volatility, and, consequently, with some degree of overreaction [...] the Board of the central bank deems it prudent to provide a greater supply of currency hedging instruments and liquidity in foreign currency, in order to facilitate the orderly operation of the foreign exchange market."[4]

The central bank announced a period of sales of foreign currency and an increase in the supply of BCDs, with $2 billion in spot market and $2 billion more of BCDs, but it also announced that the duration of the program would be four months (until February 10, 2003).

In the end, however, the central bank did not intervene in the spot market, and only issued US dollar-denominated debt. Between October 10 and February 10, the central bank issued debt equivalent to $1,440 million (less than the amount previously announced). It issued $360 million in October, $480 million in November, and $300 million in December and January (until February 10).[5]

This second episode involved much less intervention than the first one. Reserves did not change (because there was no intervention in the spot market), and sales of BCDs were 55 percent of the sales in the former intervention.

[2] Central bank communiqué, August 16, 2001.

[3] This is the total amount of BCD of the period, which includes issues from former programs.

[4] Central bank communiqué, October 10, 2002.

[5] The central bank had already announced that it would begin issuing BCDs on August 26, 2002; this listing takes into account the issues from Oct. 10 until February 10.

Third Intervention: April 10, 2008

The third intervention program was intended to increase the stock of international reserves, which the central bank considered insufficient to face a risky external scenario. It decided to intervene once the peso had appreciated 6.9 percent since the beginning of 2008.

The communiqué stated the main reason for the intervention: "This increase in the stock of international reserves will leave the Chilean economy better prepared to face the eventuality of an additional, severe and abrupt deterioration of the external environment [...] [This measure] is also consistent with the evaluation that the real exchange rate is currently below the level that should prevail once real and financial conditions in the world economy return to normal."[6]

On this occasion, the central bank gave more details of the program. It announced that it would increase the stock of international reserves by $8 billion. The program would start on April 14 and end on December 12. It also stated that it would announce the specific purchase program, which could be modified according to market conditions, starting with daily purchases of $50 million of foreign currency, which was maintained, unmodified, until the end.

The program ended earlier than planned, on September 29, because of the collapse of Lehman Brothers, when the central bank had increased its international liquidity position by $5.75 billion (equivalent to 70 percent of the initial announced amount).[7] Figure 8.2 shows that the reserves-to-GDP ratio increased by 4.4 percentage points (from 9 to 13 percent).

Fourth Intervention: January 3, 2011

At the time of the fourth intervention, the currency had appreciated by 14.4 percent in the last six months of 2010. In this scenario, the central bank stated: "The international economy shows an unusual configuration, characterized by high commodity prices, low interest rates, slow recovery of developed economies, and depreciation of the US dollar. On the other hand, emerging economies are growing vigorously and their currencies are appreciating [...] There is also the risk that the difference in the growth rate between advanced and emerging economies will be maintained beyond expectations, which could intensify the exchange pressures."[8]

To strengthen their international liquidity position, the central bank board decided to initiate another foreign currency purchase program. In its announcement, it explicitly said that the objective was to bring international reserves to a level compatible with the values observed in similar economies, for precautionary reasons. It stated: "The availability of additional reserves will allow us to better face the eventuality of a significant deterioration of the external environment [...] This program would lead the international liquidity position to 17% of GDP."

[6] Central bank communiqué, April 10, 2008.

[7] Central bank communiqué, September 29, 2008.

[8] Central bank communiqué, January 3, 2011.

The central bank announced that it would increase the level of reserves by $12 billion, with daily purchases of $50 million of foreign currency during the rest of the year. The announcement explained that the first stage of the program would consist of daily purchases of $50 million, which could be modified. However, the strategy was kept unmodified until the end of the program. As Figure 8.2 shows, when the program ended, these reserves had up to 17 percent of GDP, equivalent to an increase of $12 billion (daily purchases over 240 days).

There are other episodes that could arguably be termed *interventions*—in late 2008 and late 2017. The first corresponds to the aftermath of Lehman Brothers' bankruptcy, when a series of US dollar swaps was offered to provide short-term liquidity in foreign currency: "The Central Bank of Chile will reactivate foreign exchange swap tenders as from tomorrow, when financial conditions will be announced prior to the opening of the market."[9] The second case corresponds to an offer of US dollar swaps (up to $500 million in each tender). The central bank board announced this new program "to facilitate the normal operation of the monetary market in exchange currency [...] The program will be transitory, so it will be valid for a period of four weeks."[10] Nevertheless, in the end, these swaps were not used.

These two episodes did not involve changes in the net asset position in foreign currency of the central bank. In that sense, there were more liquidity measures than foreign exchange interventions, so this chapter does not study them (see Claro and Soto (2013) for a more in-depth discussion).

INTERVENTION IMPACT ON EXCHANGE RATES

Several well-known identification issues are present when trying to estimate the effects of intervention on the exchange rate (such as the two-way causality mentioned in Daude, Levy-Yeyati, and Nagengast 2016), which preclude the proper identification of those effects.

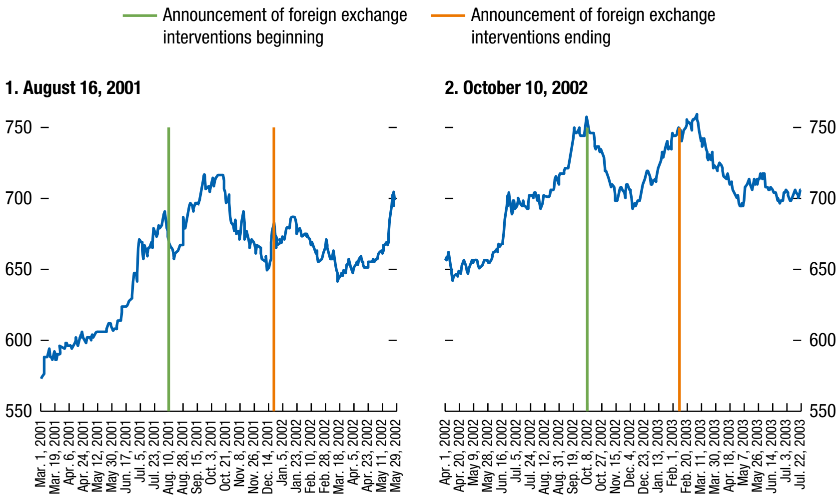
One way of addressing these issues is to use high-frequency data to run event studies. This chapter follows that strategy to estimate the effects of announcements and actual interventions on the exchange rate, trends, and volatility during the four intervention episodes.

Other studies have analyzed the effect of the interventions in Chile on the exchange rate. For example, Tapia and Tokman (2003) conducted an event study with daily data for the interventions of 2001 and 2002. BIS (2014) ran an event study with intraday data to see the effectiveness of the interventions in 2008 and 2011, and Pincheira (2013), among other goals, analyzed the effect of the announcement and actual interventions of 2008 and 2011 on the level of exchange rate (it first looks at the intraday exchange rate around each announcement and then estimates the effect of announcements and actual interventions on daily exchange rate). Also, Contreras, Pistelli, and Saez (2013) also conducted an event study for several countries, including Chile in 2011. This chapter uses an identification strategy similar to those works.

[9] Central bank communiqué, September 29, 2008.

[10] Central bank communiqué, December 15, 2017.

Figure 8.3. Interventions: Sale Announcements, 2001 and 2002
(Chilean pesos per US dollar, observed Central Bank of Chile)



Source: Central Bank of Chile.

We estimate the following regression:

$$Y_t = \beta_0 + \beta_1 Post^j + \varepsilon_t, \qquad (4.1)$$

where Y corresponds to the logarithm, the variation, or the standard deviation of the nominal exchange rate, respectively.[11] The events correspond to announcements or actual interventions (sales or purchases), j corresponds to the period before and after the event, and the variable *Post* corresponds to a dummy that takes the value of 1 if the observation is after each episode, but inside the window of size j, and zero otherwise. So, β_1 denotes the effect of each event on level, trend, or volatility of the nominal exchange rate.

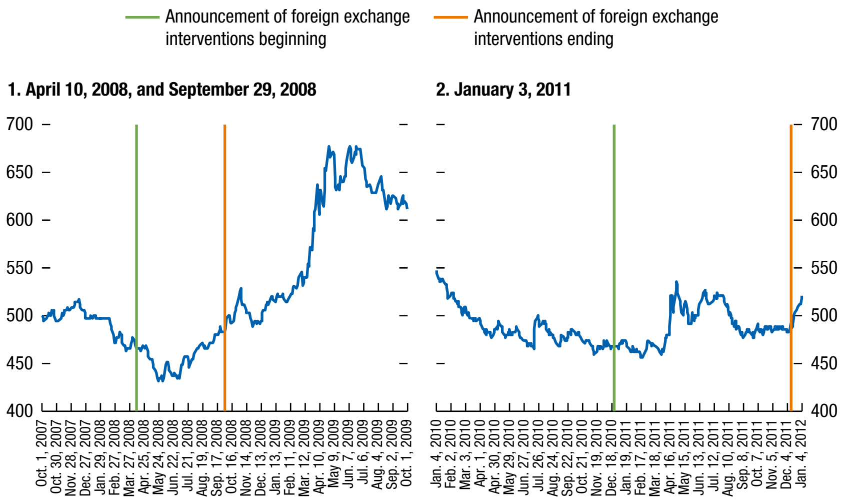
Announcement Effects: Event Study with Daily Data

This section presents the results of the event study around each announcement date using daily data for different window sizes j = {1, 2, 3, 5, 10, and 15} days before and after the event. It also estimates the effects of the early ending of the third program, in September 2008.

This analysis starts by looking at the movements of the exchange rate around the announcement dates, presented in Figures 8.3 and 8.4. It then runs the event study regressions, with results in Table 8.1.

[11] For the logarithm, the dependent variable is rescaled, so the coefficients show percentage changes.

Figure 8.4. Interventions: Purchase Announcements, 2008 and 2011
(Chilean pesos per US dollar, observed Central Bank of Chile)



Source: Central Bank of Chile.

Figure 8.3 presents the analysis of the first two announcements of intervention (sales). Panel 1 shows that, after the first announcement, the exchange rate did appreciate, showing a change in its tendency. Apparently, the effect did not last long: the exchange rate appreciated by 3.9 percent during August 15–30, with the maximum daily appreciation of 1.8 percent on August 20. This effect was then offset by a depreciation in September (as a result of the 9/11 events) and October, followed by appreciations again in November and December. The total effect from the date of the announcement to the end of the program was an appreciation of 3.42 percent.

Panel 2 of Figure 8.3 shows that the tendency of the daily exchange rate also changed around the date of the second announcement. After that, the maximum level of appreciation was reached two months later (December 13, 6.97 percent), but that appreciation was almost completely undone in the following months. At the end of the program, the exchange rate had appreciated by only 0.5 percent.

Figure 8.4 shows the path of the exchange rate around the purchase announcements. Panel 1 shows that the tendency of the exchange rate around the third announcement of intervention did change, from appreciation to a persistent depreciation, so when the program ended, the exchange rate had reached 23.5 percent depreciation since its onset. Note that this program ended sooner than originally planned because of the beginning of the financial crisis (with the associated depreciation of the currency).

Panel 2 of Figure 8.4 shows that the movement around the last announcement was different. The exchange rate jumped, and then continued appreciating. Two

TABLE 8.1.

Event Study of Announcement: Daily Exchange Rate

	Level			Daily Variation (%)			Volatility		Window Size	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Announcement	**Before**	**After**	**β_1 (%)**	**Before**	**After**	**β_1**	**Before**	**After**	**β_1**	
Program I	683.85	690.99	1.03	0.54	0.31	−0.23				1
	682.03	684.8	0.4	0.36	−0.74	−1.10				2
	681	682.24	0.18	0.19	−0.57	−0.76	2.56	7.61	5.05	3
	680.03	677.67	−0.35	0.28	−0.60	−0.88**	2.43	8.46	6.03	5
	677.02	670.19	−1.02*	0.29	−0.47	−0.76***	4.26	9.94	5.68	10
	672.81	667.98	−0.72	0.24	−0.22	−0.46**	7.17	8.70	1.53	15
Program II	744.91	756.56	1.56	0.18	0.80	0.62				1
	744.23	749.79	0.74	0.08	−0.50	−0.58				2
	744.06	748.4	0.58	0.04	−0.21	−0.25	0.74	7.19	6.45	3
	743.8	747.2	0.46	−0.04	−0.11	−0.07	0.76	5.37	4.61	5
	745.18	743.85	−0.18	−0.02	−0.22	−0.20	1.88	6.10	4.22	10
	742.81	740.58	−0.30	0.21	−0.15	−0.36*	6.92	6.89	−0.03	15
Program III	437.15	434.17	−0.68	0.73	−0.30	−1.03				1
	435.57	441.42	0.13	0.09	1.52	1.43				2
	435.83	444.11	1.87	−0.22	1.07	1.29	1.65	8.61	6.96	3
	436.93	448.42	2.58**	−0.05	0.94	0.99	2.16	8.54	6.38	5
	438.77	450.96	2.73***	−0.31	0.23	0.54	3.37	7.07	3.70	10
	440.33	452.45	2.72***	−0.02	0.40	0.42	6.17	6.65	0.48	15
	539.41	552.47	2.39	−0.13	2.31	2.44				1
End of Program III	539.76	539.89	2.22**	0.55	1.05	0.50				2
	537.71	553.11	2.83**	0.47	0.96	0.49	3.57	2.20	−1.38	3
	538	559.84	3.97**	−0.04	1.04	1.08	5.30	9.41	4.12	5
	535.62	583.16	8.4***	0.17	1.67	1.50**	5.36	28.48	23.12	10
	531.11	595.4	11.32***	0.30	0.92	0.62	8.51	29.66	21.15	15

(continued)

TABLE 8.1. *(continued)*

Event Study of Announcement: Daily Exchange Rate

	Level			Daily Variation (%)			Volatility		Window Size	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Announcement	**Before**	**After**	**β_1 (%)**	**Before**	**After**	**β_1**	**Before**	**After**	**β_1**	
Program IV	468.37	466.05	–0.50	–0.27	–0.42	–0.15				1
	469.01	476.44	1.54	–0.30	2.02	2.32				2
	469.74	482.17	2.58	–0.08	1.81	1.89	1.42	14.37	12.95	3
	469.61	487.64	3.74**	–0.06	1.22	1.28	1.02	12.65	11.63	5
	470.38	490.75	4.22***	–0.12	0.52	0.64	1.74	9.41	7.67	10
	471.69	491.07	4.02***	–0.11	0.35	0.46	2.39	7.61	5.21	15

Source: Authors' estimation based on Central Bank data.
Note: The "Window Size" column reflects the number of days for each side of the announcement date.
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

days after the announcement, the exchange rate had depreciated by 4 percent, and the maximum percentage of depreciation was reached eight days later (6.5 percent).

Table 8.1 presents the results of the event study regressions using daily data. Jointly with the estimation of the coefficients (columns 3, 6, and 9), it presents the average of preannouncement levels of each dependent variable (columns 1, 4, and 7) and postannouncement levels (columns 2, 5, and 8).[12]

The sale announcements (programs I and II) in column 3 show that the change in the level of the exchange rate is positive for small windows, and it becomes negative for bigger ones. Thus, the exchange rate continued depreciating until a few days after each announcement of intervention, although the effects are not statistically significant.

Consistently, in column 6, which presents the difference in the average daily variation of the exchange rate, the exchange rate was depreciating before each announcement, and then started to appreciate, or at least smoothed its depreciating tendency (see window size 1 in program I). Also, in window sizes $j = \{5, 10\}$ of program II, the exchange rate increased its tendency to appreciate after the announcement. These effects are significant in bigger window sizes.

The last definition of the dependent variable corresponds to the change in the volatility of the nominal exchange rate presented in column 9.[13] An increase can be seen in the volatility in both sale announcements, but the difference becomes smaller as the window size increases.

Regarding purchase announcements (programs III and IV), column 3 shows that for windows greater than one, the difference in the level of the exchange rate is positive and generally increasing (except for the biggest window size). The same phenomena in column 6 refer to the difference in the average of daily variation, reflecting a reduction in the rate of appreciation or a shift to depreciation. Also, a positive but decreasing difference in the volatility of the nominal exchange rate can be seen in column 9.

For the announcement of the end of the third intervention program, the effect on the exchange rate level is positive (column 3), as it is the difference in daily variations (column 6), which indicates that the tendency of depreciation increased after the end of the program. Also, the volatility increased sharply after this announcement—however, those results are very likely related to the turmoil of the financial crisis.

This evidence suggests that intervention announcements have the expected directional impact on the level and trend of the nominal exchange rate, and the effects are bigger for the two purchase announcements. The evidence on volatility shows that the announcement increased, rather than reduced, the volatility of the currency, suggesting that these announcements could have introduced some

[12] The β_1 coefficient is the difference of the average of the dependent variables before and after the event.

[13] The coefficients in this last estimation are the difference in volatility between the post- and preannouncement, so we cannot report the significance.

uncertainty, which tends to decrease as window sizes increase (see Claro and Soto (2013) for further discussion).

Effects of the Last Two Announcements: Event Study with Intraday Data

For these announcements, intraday data on exchange rates allow better identification of the effect of an announcement by narrowing the window of analysis around an event. This analysis closely follows the one presented in BIS (2014)[14] and in Pincheira (2013).

The announcements were published on the Chilean central bank's website, followed by a simultaneous notification to commercial banks about the recent upload. Press releases from the central bank board also explained the program, usually on the day following the announcement. The timing of these purchase announcements was the following:

- On April 10, 2008, the communiqué was uploaded at 7:15 p.m. The next day, the central bank governor published a press release at 11:00 a.m. announcing that the program of US dollar purchases would start on April 14.
- On September 29, 2008, the communiqué to terminate the program was published at 5:30 p.m., announcing the immediate cessation of the intervention. US dollar purchases were discontinued then and there.
- On January 3, 2011, the communiqué was published at 6 p.m. and the governor gave a press release on January 4 at 10:30 a.m. As explained, a program of US dollar purchases was announced, which was to start on January 5, 2011.

Figure 8.5 presents the results on the exchange rate level in a window size of $j = \{1\}$ for the day before and after each event. The preannouncement exchange rate was taken 90 minutes before the announcement, and for the postannouncement rate, two different definitions were used to compute results: (1) the first observation after the announcement (between 10 and 20 minutes after, depending on the data available for each date), and (2) the observation at 8:15 a.m. of the following day.[15]

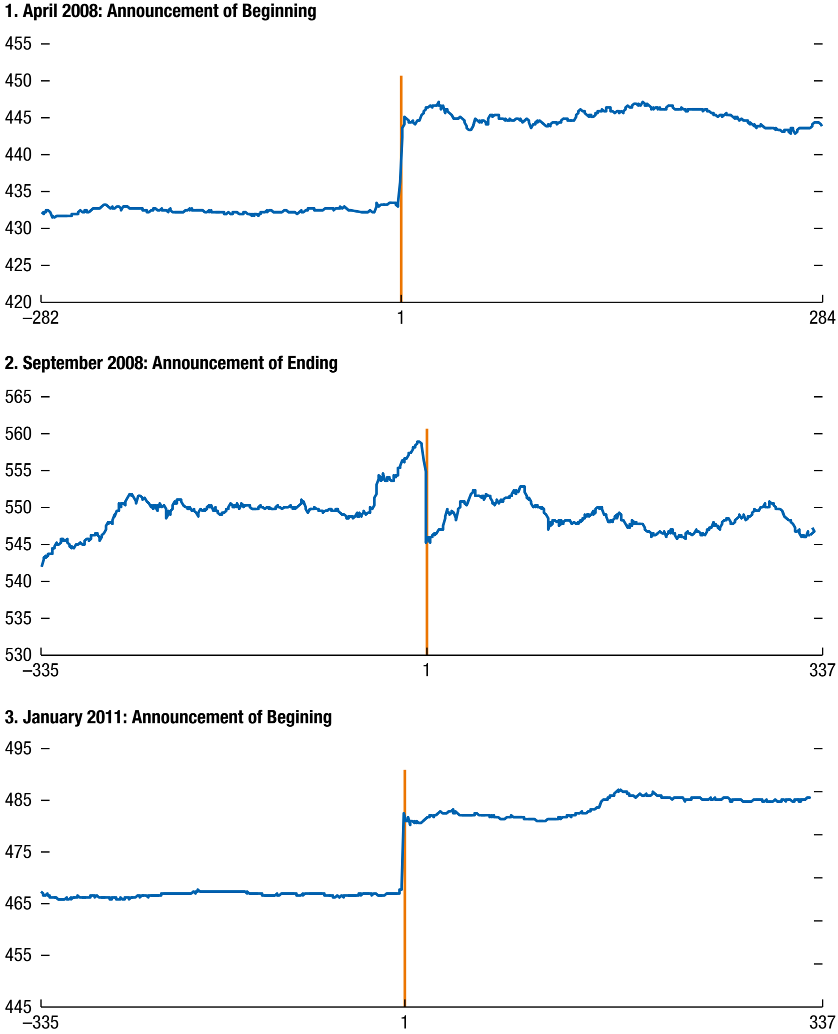
Figure 8.5 shows that at the moment of the announcement (in both cases, 2008 and 2011), the nominal exchange rate depreciated considerably. When the ending of the third program was announced, the exchange rate appreciated, as expected.

Between 90 minutes before the announcement and the first observation after the announcement, the exchange rate depreciated by 0.69 percent in April 2008, and by 4 percent in January 2011, and it appreciated by 2.58 percent in September 2008.

[14] The database of the intraday nominal exchange rate of *La Bolsa Electrónica Chile* was used, but keeping the first observation per minute in the cases that had more than one observation in a minute.

[15] This is because of different data availability for the different days of announcements.

Figure 8.5. Intraday Effect, 2008 and 2011
(Chilean pesos per US dollar)



Source: Bolsa Electrónica de Chile.
Note: The "1" represents the first observation after the announcement, so the effects are reflected on the orange line.

Also, because the announcements were made in the late afternoon, the same observation before the announcement (90 minutes before) is compared with the observation at 8:15 a.m. of the following day: The exchange rate depreciated by 3.43 percent in April 2008, and 3.68 percent in January 2011, and it appreciated by 2.39 percent in September 2008.

Event Study of US Dollar Sales in Spot and BCD Markets (2001 and 2002–03)

This section assesses the effect of actual interventions by running a daily event study (defined in regression 4.1) around the days of sale of foreign currency and BCDs. The number of observations is small, so the significance has to be taken with care.

The analysis is not done with daily data for purchases, because they took place every day, which reduces the capacity to identify the effects of a particular operation. As explained below, in those cases, the analysis runs event studies with intraday data. The analysis is done for each type of sale (spot and BCD), for window size $j = \{1, 3\}$ days and for the dependent variables: level, trend, and volatility of the nominal exchange rate (Table 8.2).[16]

To improve the identification capacity of the exercise, the sample is restricted to those interventions with at least two days between them, in the case of a one-day window, and four days for a three-day window.[17] In that sample, 54 dates of sales are in the one-day window size, and 12 are in the three-day window size.

Table 8.2 shows that the level and the daily variation effects were small and not statistically significant; they also varied across different window sizes. For the volatility, it is found that, if anything, it increased after the selling operations of BCDs in 2001.

The small impact on the level and the trend of the exchange rate is not surprising, given the intervention strategy of these programs, in which the central bank gave information about the interventions days before starting them. These findings are consistent with Tapia and Tokman (2003), who determined that the effects of the interventions came from the announcements and not from the actual interventions.

Event Study of US Dollar Purchases (2008 and 2011)

This section assesses the effectiveness of the actual purchases of US dollars on the programs of 2008 and 2011. It runs the event study regression (4.1) with the same three specifications of the dependent variable as before. As these programs consist of daily purchases, it relies on the intraday data of the nominal exchange rate to estimate the event study, and it runs the previous regression separately for each day of intervention.

Tables 8.3–8.5 report the average of the estimated coefficients, by year and by quarter.

[16] The exception is for the one-day window size, where the effect on volatility is not estimated, because it is only one day before and after each intervention.

[17] For the three-day window size, only sales of BCDs in 2001 and 2002–03 are presented, because all spot sales took place in less than four days between them. The regressions were run separately for BCDs and spot dates.

TABLE 8.2.

Event Study of Spot and (Central Bank Dollar-Denominated Bond) Sales: One-Day Window Size

		Level			Daily Variation (%)			Volatility			Window Size
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Events	No. of Observations	Before	After	β_1 (%)	Before	After	β_1	Before	After	β_1	
Spot 2001	4	673.26	676.23	0.47	−0.34	0.15	0.49*				1
BCD 2001	26	684.82	683.82	−0.21	−0.17	−0.07	0.1				1
BCD 2002–03	24	718.93	718.31	−0.08	−0.06	−0.02	0.04				1
BCD 2001	4	681.97	683.73	0.25	0.22	0.01	−0.21	1.84	3.89	2.05***	3
BCD 2002–03	8	713.95	717.94	0.55	0.20	0.12	−0.08	2.74	3.43	0.69	3

Source: Authors' estimation is based on central bank data.

Note: The "Window Size" column reflects the number of days for each side of the sale operations date.

$^*p < .1$; $^{***}p < .01$.

TABLE 8.3.

Event Study of Purchases, 2008 and 2011: Level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2008	**2008:Q2**	**2008:Q3**	**2011**	**2011:Q1**	**2011:Q2**	**2011:Q3**	**2011:Q4**
10 minutes	0.12*	0.20**	0.05	−0.01	−0.01	−0.03	0.03	−0.02
	(0.69)	(0.71)	(0.68)	(0.47)	(0.43)	(0.38)	(0.53)	(0.56)
1 hour	0.11	0.19**	0.03	0.00	−0.03	−0.03	0.06	0.01
	(0.73)	(0.73)	(0.73)	(0.49)	(0.45)	(0.38)	(0.55)	(0.57)
2 hours	0.11	0.20**	0.04	0.00	−0.03	−0.03	0.06	0.01
	(0.74)	(0.73)	(0.73)	(0.49)	(0.46)	(0.38)	(0.55)	(0.56)
Rest of day	0.12*	0.21**	0.04	0.01	−0.03	−0.03	0.08	0.00
	(0.75)	(0.76)	(0.74)	(0.50)	(0.48)	(0.38)	(0.58)	(0.56)

Source: Authors' estimation based on central bank data.
Note: Values shown are β_1 (standard errors). The "Window Size" column reflects the amount of time before 9 a.m. and after 1 p.m. Intraminute variation was too small, so now variation corresponds to the variation between the first and last observation per window.
*$p < .1$; **$p < .05$.

TABLE 8.4.

Event Study of Purchases, 2008 and 2011: Variation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2008	**2008:Q2**	**2008:Q3**	**2011**	**2011:Q1**	**2011:Q2**	**2011:Q3**	**2011:Q4**
10 minutes	−0.02	0.03	−0.06**	0.00	−0.01	0.01	−0.02*	0.02
	(0.18)	(0.18)	(0.18)	(0.12)	(0.11)	(0.10)	(0.11)	(0.16)
1 hour	0.00	0.01	−0.02	−0.01	−0.01	−0.02	−0.05	0.06
	(0.38)	(0.36)	(0.41)	(0.36)	(0.28)	(0.22)	(0.50)	(0.40)
2 hours	0.00	0.00	0.00	0.00	0.02	−0.02	−0.02	0.02
	(0.39)	(0.36)	(0.42)	(0.40)	(0.32)	(0.24)	(0.52)	(0.48)
Rest of day	−0.02	0.00	−0.03	−0.01	0.01	−0.03	−0.02	0.00
	(0.45)	(0.37)	(0.52)	(0.44)	(0.38)	(0.31)	(0.54)	(0.52)

Source: Authors' estimation based on central bank data.
Note: Values shown are β1 (standard errors). The "Window Size" column reflects the amount of time before 9 a.m. and after 1 p.m. Intraminute variation was too small, so now variation corresponds to the variation between the first and last observation per window.
*$p < .1$; **$p < .05$.

The purchases were made between 9 a.m. and 1 p.m., so observations before 9 a.m. are compared with the ones after 1 p.m., using different window sizes j = {10 minutes, 1 hour, 2 hours, and all the observations until the end of the day}.[18]

[18] The windows are truncated from the left because they start when the market opens.

TABLE 8.5.

Event Study of Purchases 2008 and 2011: Volatility

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2008	**2008:Q2**	**2008:Q3**	**2011**	**2011:Q1**	**2011:Q2**	**2011:Q3**	**2011:Q4**
10 minutes	−0.02	−0.03	0.00	−0.03***	−0.03*	−0.03**	−0.02	−0.06**
	(0.18)	(0.17)	(0.20)	(0.12)	(0.12)	(0.10)	(0.11)	(0.16)
1 hour	−0.19***	−0.15***	−0.22***	−0.10***	−0.03	−0.10***	−0.15***	−0.14***
	(0.41)	(0.35)	(0.46)	(0.25)	(0.20)	(0.14)	(0.24)	(0.36)
2 hours	−0.12***	−0.10*	−0.15**	−0.04**	0.02	−0.06***	−0.07**	−0.06
	(0.45)	(0.38)	(0.51)	(0.26)	(0.21)	(0.15)	(0.24)	(0.41)
Rest of day	0.04	0.06	0.02	0.08***	0.11***	0.01	0.08*	0.14**
	(0.54)	(0.44)	(0.62)	(0.30)	(0.21)	(0.18)	(0.35)	(0.41)

Source: Authors' estimation based on central bank data.
Note: Values shown are β_1 (standard errors). The "Window Size" column reflects the amount of time before 9 a.m. and after 1 p.m. The intraminute variation was too small, so now variation corresponds to the variation between the first and last observation per window.
$*p < .1$; $**p < .05$; $***p < .01$.

Table 8.3 shows the percentage change in the nominal exchange rate. The effects are small and statistically significant only for some cases in 2008, where the coefficients have the expected sign. Table 8.4 shows that the effects on the variation of the exchange rate are again not significantly different from zero.

For exchange rate volatility, Table 8.5 shows negative and significant effects for 2008, but results are less clear for 2011, since the signs vary across different window sizes. This is consistent with BIS (2014), which found no significant effects on the trend of the exchange rate when considering a narrow time period around the actual interventions.

COMMUNICATION

Central bank communication of the interventions to the market varied across regimes. When the exchange rate band was operating, the central bank did not communicate the spot interventions to the market. However, since the central bank adopted inflation targeting, it communicates the interventions, although their content varied across the four intervention episodes.

The first two interventions established the maximum reserves to be sold, but only the second one announced the duration of the program. In neither of them did the central bank communicate the daily spot or BCD interventions, but it published the foreign reserves two weeks after the interventions occurred. The two subsequent episodes, however, explicitly established the amount to be purchased, the starting date and the duration, along with the daily schedule.

In addition, for the last two episodes, the central bank made it clear that it would reserve the right to alter the program whenever it deemed necessary. As we already explained, that was the case in September 2008. The communiqué explicitly stated that "[the program] could be modified according to market conditions" and the one in 2011 stated that "[stages of the program] could revise them according to market conditions."

Also, the central bank board communicated to the market the main reason(s) for each intervention, which, in the first two cases, were related to an overreaction of the level and volatility of the currency because of financial stress in other economies in the region. In the last two cases, the interventions were related mainly to an accumulation of reserves for precautionary reasons.

In addition, the four communiqués highlight the commitment of the central bank to its inflation target. In the first two announcements, the central bank said that the board reiterates its confidence in the Chilean economy and in the effectiveness of the macroeconomic policy framework. In the last two announcements, it was even more explicit in its commitment to the inflation-targeting regime, stating in 2008 that "this exceptional measure is coherent with the overall conduct of monetary policy, which aims to keep inflation at 3% most of the time, within a tolerance range of ±1%." In 2011 it ended by saying: "The Board of the Central Bank reiterates its commitment to the conduct of monetary policy, based on an inflationary goal and exchange rate flotation [...] our flotation scheme allows interventions in exceptional situations."

LESSONS FROM CHILE

Implementation of the free-floating regime made the inflation target more credible and the economy more resilient to external shocks. Interventions are a risk for an inflation-targeting regime, because if there are too many of them, central banks can lose credibility on their commitment to the target. One of the main lessons of the Chilean experience is that interventions need to be rare and occur only in extraordinary circumstances.

The method of communicating interventions is also relevant. Transparency and clear public explanation is crucial. If interventions are not transparent, the temptation to intervene more frequently increases. This transparency, without conditioning it to the evolution of the exchange rate, reflects the commitment of the Central Bank of Chile to exchange rate flexibility.

The central bank on its website states that "such interventions are transparent, sound, and exceptional measures. When they occur, the timings and amounts involved are explicitly defined, and the reasons are clearly stated."[19]

[19] See http://www.bcentral.cl/web/guest/flexibilidad-cambiaria.

CONCLUSION

After decades of experimenting with fixed, multiple exchange rates and crawling pegs, in 1999 the Central Bank of Chile abandoned exchange rates as a policy goal, which left the inflation rate as the only target.

Chile has a full inflation-targeting regime that rests on a central bank commitment to exchange rate flexibility. Since this adoption, the central bank has intervened in the foreign exchange market four times. The first two (2001 and 2002–03) responded to an overreaction of the exchange rate and its volatility because of difficult situations in neighboring countries, and the last two (2008 and 2011) responded to a desire to build up the stock of foreign reserves for precautionary reasons.

In each case, interventions were preannounced, along with the maximum amount of sales/purchases in spot markets and BCD, the beginning and ending dates of the intervention period (except for the first episode of intervention), and a daily schedule for the program in the last two cases.

The evidence indicates that the announcements have a short-run effect on the nominal exchange rate and trend, and those go in the expected direction, with bigger effects for the last two announcements (purchases). Also, no significant effect of actual interventions was found on the level and trend of the nominal exchange rate. For volatility, the analysis found that, if anything, the four announcements and the actual selling interventions tended to increase the volatility of the nominal exchange rate.

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CHAPTER 9

Learning from Experience in Colombia

Pamela Cardozo

This chapter describes the mechanisms used by the Central Bank of Colombia for intervention in the foreign exchange market and explains the rationale and operations. The text characterizes the instruments used to sterilize the monetary effects of US dollar purchases, as well as the effects of the sterilized intervention on the central bank's balance sheet. At the end, a short survey of the effectiveness of foreign exchange sterilized intervention in Colombia is presented.

INTRODUCTION

The policy strategy of *Banco de la República*, Colombia's central bank, seeks to maintain a low and stable inflation rate while keeping production levels close to their potential value.[1] The central bank's policy also helps maintain financial stability and adequate functioning of the payments system.

Exchange rate flexibility is fundamental to achieve these objectives for a number of reasons. First, in a flexible exchange rate regime, the exchange rate serves as an adjustment variable against the shocks faced by the economy, which reduces volatility in economic activity.[2] Second, exchange rate flexibility allows the interest rate to be used independently as a tool to guide inflation and production to their desired values. Third, exchange rate flexibility reduces incentives for excessive foreign currency risk taking by economic agents, a reduction that is vital for maintaining financial stability.

However, the central bank, as the foreign exchange authority, can intervene in the foreign exchange market. Such intervention does not limit exchange rate flexibility, nor does it aim to achieve any specific exchange rate value. It pursues

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The opinions expressed in this chapter are the sole responsibility of the author and are not necessarily those of the Banco de la República or its Board of Directors.

[1] See http://www.banrep.gov.co/es/politica-intervencion-cambiaria (similar text available in Spanish).

[2] As an illustration, the Inter-American Development Bank (2016) compares the response of Ecuador, which is a dollarized economy, and Colombia to the drop in oil prices. This commodity is very important for both countries.

objectives compatible with the strategy of inflation targeting. The central bank intervenes in the foreign exchange market to (1) increase international reserves to reduce external vulnerabilities and improve access to foreign credit, (2) mitigate fluctuations in the exchange rate that do not clearly reflect the behavior of fundamental economic variables and that may have an adverse impact on inflation and economic activity, and (3) provide foreign liquidity to the market to ensure normal functioning of internal and external payments.

To guarantee the compatibility of foreign exchange intervention with the inflation-targeting strategy, purchases and sales of US dollars are sterilized as needed to stabilize short-term interest rates at a level that the central bank's board considers coherent with its inflation and output objectives.[3,4] This means that monetary expansions or contractions, generated by purchases or sales of US dollars, are compensated to avoid deviations of the overnight banking indicator interest rate ("IBR" in Spanish) from the level prescribed by the board.

An intervention decision considers its benefits and its costs for the country, as well as its effect on the central bank's financial position. Holding international reserves and sterilizing reserve purchases is costly, especially when the domestic interest rate is higher than the return on reserves, which is the case for most emerging market economies.

This chapter first describes the foreign exchange purchase mechanisms used by the central bank in the period of the flexible exchange rate regime, and it explains their rationale and operation. It then characterizes the instruments used to sterilize the monetary effects of those purchases, as well as the effects of the sterilized intervention on the central bank's balance sheet. Next, the current decision-making process to buy reserves is described, and the criteria for both the timing and the intensity of the purchases is specified. The next section turns to sales of international reserves, and it focuses on both the mechanisms used and the current decision-making process. A short survey of the effectiveness of foreign exchange sterilized intervention in Colombia is presented at the end of the chapter.

PURCHASES OF RESERVES AND VOLATILITY OPTIONS

On September 25, 1999, Colombia shifted from a crawling band to a flexible exchange rate regime, and in December of that year, it committed to a stabilization program with the IMF, amid a difficult macroeconomic environment. Part of that program was to restore international reserves to an adequate level. The central bank then started to offer put options to satisfy this requirement.

[3] The strategy has been in place since 1999.

[4] Purchases and sales of US dollars were not fully sterilized during the first years of the inflation-targeting regime.

Put Options to Accumulate Reserves

Put options to accumulate reserves was adopted based on Mexico's experience. The Colombian central bank auctioned these options at the end of each month (from November 1999 to September 2002, March to August 2003, March to May 2008) to banks, financial corporations, and the Ministry of Finance (this group is known as intermediaries of exchange rate options).[5] These were US options with one-month maturity and a strike price equal to the representative market Colombian peso/US dollar exchange rate (TRM in Spanish).[6] Given that the objective was solely to accumulate reserves, agents could only exercise the options when the TRM was below its 20-day average. The central bank could then avoid buying US dollars when the Colombian peso was weaker than the previous 20 days.

This is a suitable mechanism for countries that need to accumulate reserves and want to minimize the effect of reserve accumulation on the exchange rate. Through these auctions, the central bank bought $3.4 billion.[7] All 49 auctions were oversubscribed, and the minimum and maximum amounts offered were $30 million and $250 million, respectively. During the first years, the amount auctioned was guided by the goals established in the agreement with the IMF. In October 2002, the central bank suspended this mechanism to avoid potential pressure on the exchange rate, given the depreciation of the peso (23 percent from April to October 2002).

From December 2002 to January 2004, the central bank carried out five of these auctions (denoted by blue stars in Figure 9.1), but not monthly or at the end of the month. Monthly auctions were reactivated in March 2004, because the appreciation of the peso was seen as transitory. At that moment, additional accumulation of international reserves was considered prudent to face any possible sudden reversals in capital flows or overadjustments in the exchange rate that could affect future inflation behavior.

When the central bank decided to shift to a flexible exchange rate regime, it introduced an intervention mechanism, known as volatility options, to provide coverage mechanisms to agents against extreme exchange rate movements. At that moment, the central bank considered the market unprepared to offer hedges under extreme circumstances.

Volatility Options

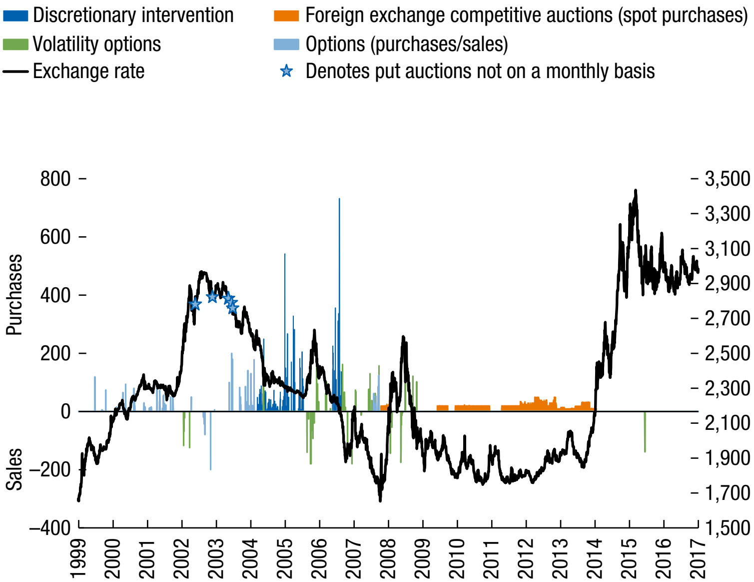
The central bank publicly committed itself to offer, through auctions, call (put) options with one-month maturity to intermediaries of exchange rate options,

[5] This group also includes finance companies and financial cooperatives that have larger-than-required technical equity to establish a financial corporation.

[6] The TRM is calculated as the weighted (by quantity) average of Colombian peso/US dollar spot operations of the previous day.

[7] The central bank announced exercised options daily.

Figure 9.1. Colombian Central Bank Foreign Exchange Intervention, 1999–2017
(Millions of US dollars, left scale; US dollar/Colombian peso official exchange rate, right scale)



Source: Central Bank of Colombia.
Note: Data are from September of each year.

whenever the TRM was higher (lower) than its 20-day moving average plus (or minus) 5 percent.[8] The threshold took into account a low probability of activation. The strike price was the TRM, and the condition for being able to exercise the option was the same as for the activation of the auction.

Considering that the objective was to mitigate an extreme fluctuation, the amount auctioned was large in comparison to the market. From 1999 until October 2001, it was $120 million.[9] The central bank changed the offered amount to $180 million, given the increase in the volume of the foreign exchange market, and the threshold to 4 percent, since 5 percent seemed too extreme, given the behavior of the peso under the flexible exchange rate regime.

[8] The central bank was committed only if the maturity of the last options had expired.

[9] The objective was to intervene with 50 percent of the market volume on the days the options were "in the money." The data showed that past options would have been, on average, 4 days in the money.

TABLE 9.1.

Volatility Auctions

Period	Trigger (%)	No. of Obliged Call Auctions	No. of Obliged Put Options	No. of Discretionary Call Options	No. of Discretionary Put Options
Nov. 1999–Oct. 2001	5	0	0	n/a	n/a
Oct. 2001–Dec. 2005	4	2	1	1	0
Dec. 2005–Jun. 2008	2	5	11	4	4
Jun. 2005–Oct. 2008[1]	n/a	n/a	n/a	n/a	n/a
Oct. 2008–Oct. 2009	5	2	5	3	0
Oct. 2009–Oct. 2011[1]	n/a	n/a	n/a	n/a	n/a
Oct. 2011–Feb. 2012	4	0	0	n/a	n/a

Source: Central Bank of Colombia.
Note: Trigger refers to the threshold established to activate the auction and needed for the exercise of the auction. n/a = not applicable.
[1]The central bank was buying reserves daily.

The first volatility auction (call options) was on July 29, 2002. Agents exercised all options in two days. On August 1, 2002, the condition for activation was met, and the central bank offered $180 million through call options.[10] The first put volatility auction was held in December 2004.

The central bank again changed the threshold to 2 percent in December 2005. With such a small threshold, it had to do 5 call and 11 put option auctions. Discretionally, when the condition was reached but the maturity of the central bank's options had not expired, the central bank did four additional call and put option auctions.

This mechanism was suspended from June to October 2008 and from October 2009 to October 2011, because the central bank was buying US dollars daily (as explained later). In February 2012, when the central bank resumed buying US dollars daily, it put off the mechanism again, which at that moment had a threshold of 4 percent (Table 9.1) and an amount of $200 million (20 percent of daily traded volume).

The last volatility option was conducted under a slightly different mechanism: only the volatility call option instrument was turned on.[11] The Colombian peso was at its weakest value historically, and therefore the central bank did not want to have to buy reserves at all. This variant was implemented in November 2015, after the peso had depreciated substantially in response to the collapse in the oil price.[12] The purpose of the mechanism was to mitigate expectations of

[10] This auction was under the central bank's discretion, given that the maturity of the previous options had not expired.

[11] For simplicity, the central bank presented this auction as a call option for the deaccumulation of reserves.

[12] From June 2014 to October 2015, the peso depreciated 53 percent in response to the decline of the price of oil (56 percent).

depreciation and inflation, as the latter significantly exceeded the target, and to provide liquidity to the market under an extreme depreciation.[13,14]

The central bank established the threshold at 7 percent. To impact expectations, the amount offered was $500 million (50 percent of daily traded volume). Later, the threshold changed to 5 percent and then to 3 percent. At this last threshold the condition was achieved. On May 20, 2016, the central bank offered $500 million in call options. Agents demanded $411 million and exercised $256 million. The central bank deactivated the mechanism at the end of May, when liquidity in the market was adequate.

To sum up, volatility options seek to mitigate extreme short-term exchange rate movements, but they are not meant to moderate trends. If policymakers activate this mechanism with the aim of intervening in the market, they will have the tendency to lower the threshold when the intervention has not been activated.

From 1999 to 2003, Colombia's de facto regime was classified as independently floating, according to the IMF.[15] Since 2004, it has been in the floating category.[16] One of the IMF's reasons to change Colombia's de facto classification was likely the shift from rules-based mechanisms to discretionary purchases of US dollars.

Discretionary Purchases

Despite the accumulation of reserves between December 2003 and September 2004 ($1.4 billion), the Colombian peso appreciated 8 percent. The central bank therefore opted for another mechanism, discretionary intervention, to accumulate reserves to mitigate the appreciation trend. On September 17, 2004, the central bank announced that it was going to buy up to $1.0 billion by the end of the year, directly in the market (as another participant) and through put options for accumulation of reserves, considering the negative effects that a stronger peso could have on some tradable sectors.[17] On December 21, 2004, after an extraordinary board meeting, the central bank ratified its discretionary purchases without

[13] Expectations stood at 4.12 percent, the highest since February 2012, while the target was 3 percent.

[14] Some liquidity indicators (such as market depth and bid-ask spreads—not the traded amount) showed an important deterioration.

[15] "The exchange rate is market-determined, with any official foreign exchange market intervention aimed at moderating the rate of change and preventing undue fluctuations in the exchange rate, rather than at establishing a level for it. In these regimes, in principle, the authorities may pursue an independent monetary policy." See https://www.imf.org/external/np/mfd/er/2003/eng/0603.htm.

[16] "A floating exchange rate is largely market determined, without an ascertainable or predictable path for the rate. Foreign exchange market intervention may be either direct or indirect, and such intervention serves to moderate the rate of change and prevent undue fluctuations in the exchange rate, but policies targeting a specific level of the exchange rate are incompatible with floating. Indicators for managing the rate are broadly judgmental (for example, balance of payments position, international reserves, parallel market developments). Floating arrangements may exhibit more or less exchange rate volatility, depending on the size of the shocks affecting the economy."

[17] The transactional market is semiblind (customers know their counterparty only when the transaction is executed).

mentioning any limit. From the first announcement until the end of 2004, the central bank bought $1.3 billion directly in the market (it did not auction put options). The central bank continued to buy $5.9 billion using this mechanism until March 1, 2006, when the peso started to depreciate rapidly after the US Federal Reserve increased interest rates. In press releases from the meetings of the board, until March 2006, the central bank reiterated its decision to continue intervening discretionally in the foreign exchange market.

The central bank resumed its discretionary purchases on January 15, 2007 (Figure 9.1), after an appreciation of the peso of 16 percent from July 2006.[18] At the end of January, the central bank announced that it was going to intervene massively in the exchange market to confront the transitory pressures arising from the sale of public sector assets. It bought $4.5 billion until April 2007, while the peso appreciated 5 percent. In a single day, purchases were $732 million (89 percent of the daily average traded volume in March 2007).

After all this active discretionary intervention, the central bank decided to return to announced mechanisms. It concluded that trying to defend an exchange rate level was not feasible, and the mechanism gave a sense that that was precisely what the central bank was doing.[19] On June 24, 2008, the central bank started to accumulate reserves through daily auctions of spot purchases of small amounts in comparison to the market.

Daily discretionary purchases were publicly disclosed on April 2013.[20] During the discretionary purchases, starting in February 2007, the public had access, with a 1-month lag, to the information on the quantity bought by the central bank during each month. This mechanism demanded a lot of time from staff and board.

Auctions of Spot Purchases

This mechanism was adopted based on Chile's experience. On June 20, 2008, when the Colombian peso was at its highest value historically, the central bank announced that it was changing its mechanism of accumulating reserves, from monthly put options of $150 million (12 auctions starting in March 2008) to daily auctions of purchases of $20 million.[21] The central bank said the change reinforced the policy of accumulation of reserves to face an eventual deterioration of the international environment, and that the measure took advantage of an appreciated peso that seemed unsustainable.

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[18] In the press release of December 2006, the central bank reiterated its commitment to intervene in the foreign exchange market without affecting the achievement of the inflation target.

[19] Internally, the central bank decided the exchange rate levels at which intervention should be done. They changed over time.

[20] See http://www.banrep.gov.co/es/intervencion-banco-republica.

[21] The auction lasts 3 minutes and is competitive. The details of the auction can be found at http://www.banrep.gov.co/sites/default/files/reglamentacion/archivos/Compendio_CRE_DODM_143_27_may_2016.pdf (in Spanish). All of the central bank's auctions are a uniform price.

Given the latter, with its intervention, the central bank wanted to have an effect on the exchange rate level. This seemed more likely with the daily auctions of spot purchases than with the put options. As already mentioned, agents could only exercise these put options when the peso was appreciating in comparison to the previous 20 days. Therefore, under a depreciation trend, the central bank would not be able to buy US dollars with the put option mechanism with the spot auctions it was buying every day.

On October 6, 2008, the central bank stopped purchasing US dollars through spot auctions when the peso depreciated after the financial turmoil in the United States. These auctions were reactivated in March 2010 to limit the country's risk profile by increasing international reserves. From March 2010 to December 2014, the central bank accumulated \$22,450 million (47 percent of actual reserves; see Figure 9.2, panel 1) through this mechanism.[22] Daily purchases were small in comparison to the traded volume (on average \$942 million). The maximum and minimum amounts were \$50 million and \$5 million, respectively. Usually, the central bank announced the approximate amount it was going to buy. For example, in September 2010, the board meeting press release said that the central bank was going to purchase at least \$20 million daily, for at least the next 4 months. Purchases were suspended on December 11 of 2014, given the decline in the price of oil and the ensuing large depreciation of the peso (Figure 9.1).

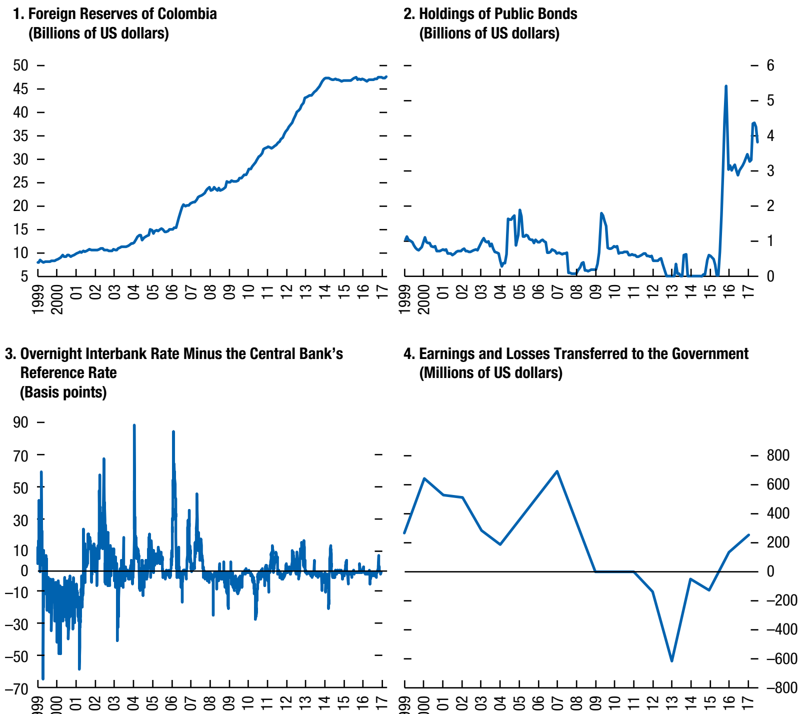
PURCHASES OF RESERVES: STERILIZATION INSTRUMENTS AND THE EFFECT ON THE CENTRAL BANK'S BALANCE SHEET

Sterilization mechanisms to contract the monetary base are a key element of the central bank's inflation targeting, so that it is able to buy international reserves, as needed, without inducing deviation of the short-term interest rate from the policy rate. The central bank might otherwise compromise the inflation target with the purchases of foreign currency. Indeed, it faced this challenge in 2007, because it was buying reserves and did not have enough securities to be sold in the market (see Figure 9.2, panel 2, on holdings of public bonds), and the law prohibited it to issue its own bonds. As a sterilization mechanism, the central bank thus offered short-term deposits, which paid an interest rate close to the policy rate. These term deposits did not attract as many resources as needed because of the lack of a secondary market. As a result, the short-term interbank overnight rate was below the policy rate during some periods (Figure 9.2, panel 3).

In 2009, the law allowed the central bank to issue its own bonds, and it added a new sterilization instrument to the toolkit. So far, it has not used it, because in 2012 it signed a memorandum of understanding with the Ministry of Finance by which the latter would issue short-term government bonds and would deposit the

[22] International reserves increased \$39.6 billion, and the central bank's net purchases were \$38.4 billion between October 1999 and November 2017.

Figure 9.2. Central Bank's Indicators, 1999–2017



The overnight interbank rate is depicted instead of the overnight IBR, because the latter exists since 2008.

*Colombian peso/US dollar movements do not affect profits and losses

Note: IBR = Indicador Bancario de Referencia (Banking Reference Interest Rate).

proceeds in the central bank, to reduce the monetary base.[23] The central bank would remunerate the Ministry of Finance's account and, therefore, would carry with the cost of sterilization. The advantage of this mechanism is that the country has only one risk-free issuer; that is, the central bank and the Ministry of Finance are not both setting prices for public bonds. The agreement also states that sterilization bonds will have, at most, a 3-year maturity. This was a concern for the central bank, considering that shorter bonds (lower market risk) could attract more foreign investors. Time has shown that foreign investors are more averse to liquidity than to market risk, and sterilization bonds are not as liquid as longer-term bonds.

Sterilization with bonds affects banks' balance sheets. According to Vargas, González, and Rodriguez (2013), if sterilized foreign exchange intervention is effective because of portfolio balance channel effects, it may also have an expansionary effect on credit supply and aggregate demand. The authors assume that banks have an optimal composition between public bonds and loans.

[23] The issuance of these bonds was authorized in Colombia's National Development Plans for 2010–14 and for 2014–18. The authorization must be included in each National Development Plan.

The sterilization of the purchases of reserves has costs that affect the central bank's balance sheet. From 2012 to 2015, the central bank produced losses as a result of the low return on international reserves and the higher cost of sterilization (Figure 9.2, panel 4). Given that, by law, the government has to assume the central bank's losses, the central bank feared that its independence might be affected. However, this did not happen.

HOW TO DECIDE THE AMOUNT AND TIMING OF PURCHASES

Until 2012, there was an important debate among the central bank's board and its staff on how many reserves to buy and when. Models of optimal reserves were not very useful, considering their high sensitivity to model parameter values (see Técnica 2014). The central bank decided to establish a framework as a basis for the discussion.

Given that there is no agreement on an adequate level of reserves, the framework takes into account the most common indicators in this regard: (1) reserves/imports, (2) reserves/(1-year external amortizations and the current account deficit), (3) reserves/(M3 and private agents' holdings of public bonds and equities), and (4) reserves/GDP.[24] The third indicator was modified 3 years ago, to take into account that residents and nonresidents (private agents) can leave the country through the liquidation of their financial investments (previously it was reserves/M3).[25] The fourth indicator is included because it is widely used for comparisons across countries. It is less relevant, however, because the vulnerability to external shocks does not depend as much on the size of the economy as it does on a country's trade and financial integration with the rest of the world.[26]

Once a set of indicators is defined, how should their adequate values be determined? This is a question for which there are no clear-cut answers. The central bank decided to take two target levels for each indicator. First, its average from 2003 onward (starting when the floating exchange rate regime was consolidated—a period in which Colombia has not experienced an external crisis). Second, the 2008 average, the year of the global financial crisis, in which Colombia did well. The central bank takes the simple average of these eight targets to determine the adequate level of reserves (Figure 9.3).

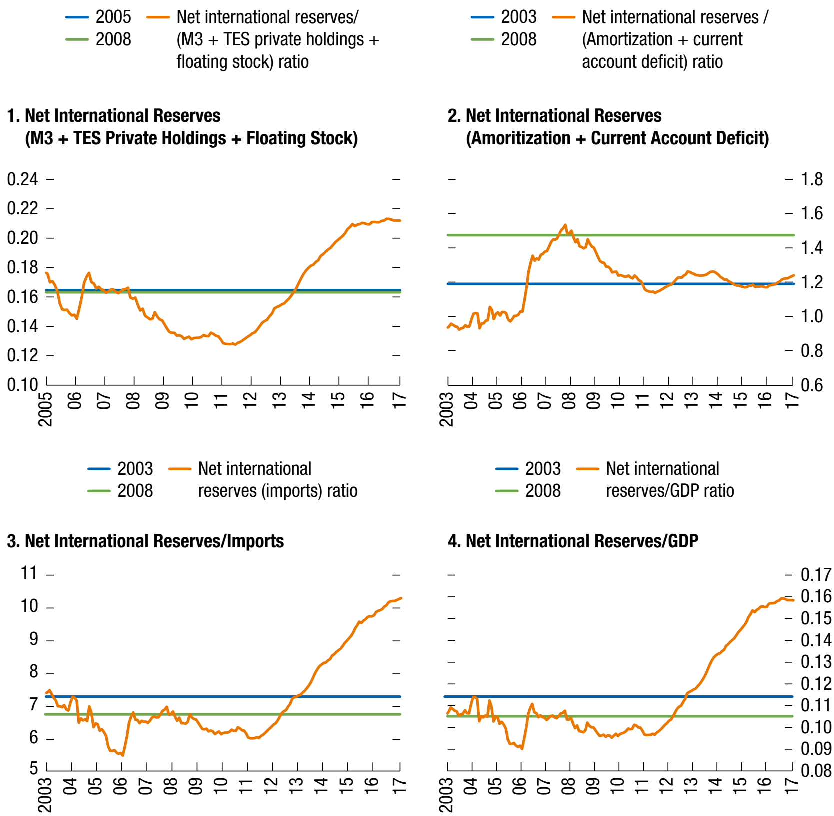
If the result of the framework's calculation suggests that the central bank should accumulate reserves, and authorities desire to confront the possibly unsustainable appreciation dynamics, then purchases should be carried out during periods when

[24] This is known as TES.

[25] Since 2014, foreign portfolio investment has been an important source of Colombia's capital account.

[26] The central bank applied the IMF method to the Colombian case to define the country's reserve adequacy. This indicator is used for comparison purposes only, because of the short length of the time series used for estimation. The estimation period starts in 2003, when the flexible exchange rate regime was consolidated. It covers the global financial crisis but does not include a crisis in Colombia.

Figure 9.3. International Reserves Indicators



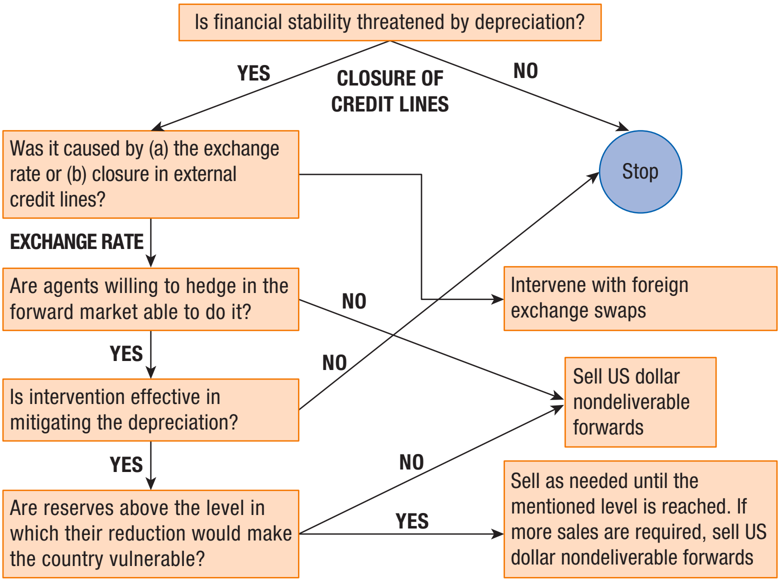
Source: Central Bank of Colombia.
Note: TES = títulos de tesorería (Treasury bills in Colombia).

the Colombian peso/US dollar exchange rate is below an estimate of its equilibrium level. The further it is from this level, the faster the pace of the purchases.

To estimate the equilibrium of the real exchange rate for intervention, the central bank uses behavioral equilibrium exchange rate models. These relate the multilateral real exchange rate with its short- and long-term fundamentals. Significant deviations of the real exchange rate from its fundamentals may reflect speculative behavior in the exchange rate market, which the sterilized intervention of the central bank might be able to correct.[27]

[27] The methods for estimating the equilibrium multilateral real exchange rate, based on purchasing power parity, show parity measures in the very long term, beyond the horizon and effectiveness of the exchange rate policy. The fundamental equilibrium exchange rate models, on the other hand, relate the equilibrium real exchange rate to measures of the "sustainable" current account deficit. This hinders its use as a tool to detect short-term misalignments, since they reflect imbalances of savings and investment that are not likely to be corrected by sterilized intervention.

Figure 9.4. Decision Tree for Selling Reserves



Source: Central Bank of Colombia.

SALES OF RESERVES

In addition to the sale of US dollars though volatility options, the central bank has also used call options as a mechanism to deaccumulate reserves. Call options were used from February to April 2003, when the peso was depreciating, to complement interest rate hikes and contain rising inflation expectations, after a substantial depreciation of the currency had taken place.[28] These options work in the same way as the put options for accumulation but can only be exercised when the TRM is above its 20-day average. Similar to put options for accumulation, call options to deaccumulate are not suitable to face an exchange rate trend.

Beyond its possible contribution to reach or maintain the inflation target, sales of international reserves can be used to help preserve financial stability. At present, central bank staff follow the decision tree shown in Figure 9.4 to determine whether the central bank should sell reserves with this aim when the peso is depreciating, and to suggest to the board which mechanism to use.

This decision tree recommends intervening through foreign exchange swaps when financial stability is threatened by closure of external credit lines (the central bank sells US dollars spot and buys US dollars forward). Through this mechanism, intermediaries of exchange rate options (central bank counterparties in the

[28] There were three auctions of $200 million each. All options were exercised.

foreign exchange swap) are not changing their foreign exposure. Therefore, the central bank's foreign exchange swaps will have a limited effect on the exchange rate, but will allow intermediaries to provide credit in foreign currency without exchange rate risk.[29, 30] This mechanism was regulated in June 2015 and has not been used so far. Since it should not prevent agents from searching external credit lines, the central bank will auction the forward contract with a maximum accepted price that is lower than the market's.

The use of the other mechanisms, sales of US dollars through nondeliverable forwards and spot sales, depends on the level of reserves and on the functioning of the derivatives market.[31] One of the advantages of nondeliverable forwards is that they do not affect the level of reserves. In many instances, the decision to pursue sterilized intervention depends on its perceived benefits, and specifically, on its effectiveness to affect the exchange rate. This is a key question in any decision tree.

EFFECTIVENESS OF INTERVENTION

Many papers analyze the effectiveness of the central bank's foreign exchange intervention to affect the level of the exchange rate or reduce its volatility (Table 9.2). Most studies use a two-stage estimation model to avoid endogeneity issues, in which a first equation describes the behavior of the official foreign interventions, and a second explains the exchange rate percentage changes.[32] Others implement techniques based on event studies.

The majority of these papers use daily data. Conclusions vary. In purchases through daily auctions, Echavarría, Melo, and Villamizar (2017) find a bigger depreciation effect compared to discretionary purchases, but Fuentes and others (2014) report that daily auctions do not affect the level of the exchange rate after some minutes have passed. Murcia and Rojas (2014) reached a similar conclusion. The biggest effect is found with volatility put options: purchases of $1 million depreciated the currency by 0.01 percent for 3 weeks. Most likely, this small and short-lived effect did not have a significant impact on key economic sectors. This result is not surprising; after all, the possibility of Colombian authorities stabilizing the exchange rate is limited, given that the country chose an independent monetary policy and a relative open capital account (the impossible trinity).

[29] On the asset side of the balance sheet, they have US dollars, and on the liabilities side, the sale of US dollar forwards.

[30] The credit will be hedged with the sale of US dollar forwards to the central bank.

[31] These have not been regulated.

[32] Foreign interventions might react to exchange rate movements as long as they influence its behavior.

TABLE 9.2.

Effectiveness of Sterilized Intervention: Nonexhaustive Evidence for Colombia, Selected Studies, 2008–17

Literature	Period	Type of Intervention	Method	Was the Intervention Effective?	How Long Was It Effective?
Kamil 2008	Sep. 2004–Mar. 2006 Jan.–Apr. 2007 (daily)	Discretionary purchases	Two-stage Tobit-GARCH	Yes, during the first period (the central bank was reducing the interest rate); $30 million generate 0.23 percent depreciation; reduces volatility No, during the second period (the central bank was raising the interest rate)	Contemporary
Echavarría, López, and Misas 2009	Jan. 2000–Aug. 2008 (monthly)	Options, volatility options, and discretionary purchases	SVAR	Yes (no size effect mentioned), given that interventions at the beginning of the sample might have not been sterilized entirely, and that, in some cases, intervention announced an expansive future monetary policy	1 month
Castro and Toro 2010	1993–2010 (daily)	All interventions (no differentiation)	Two-stage GARCH	Yes, but only between 2008 and 2010, because of the interaction between interventions and capital controls (75 days); purchases of $1 million depreciated 0.008 percent; in all other periods, volatility increases	Contemporary
Murcia and Rojas 2014	May–Sep. 2012 (intraday)	Daily purchases through auctions	EGARCH	Not in the exchange rate level 3 minutes after intervention; volatility increases	
Echavarría, Melo, and Villamizar 2014	2000–12 (daily)	Options, volatility options, and discretionary purchases	Event study	Volatility options only (direction, smoothing, reversion, matching)	Up to 10 days
Fuentes and others 2014	May 2007–Nov. 2011 (intraday)	Daily purchases through auctions	Event regressions	No (neither in level nor in volatility)	

(continued)

TABLE 9.2. *(continued)*

Effectiveness of Sterilized Intervention: Nonexhaustive Evidence for Colombia, Selected Studies, 2008–17					
Literature	**Period**	**Type of Intervention**	**Method**	**Was the Intervention Effective?**	**How Long Was It Effective?**
Durán-Vanegas 2015	June 2008–Dec. 2013 (daily)	Volatility options and purchases through daily auctions	Two-stage ARCH-GARCH	Yes, when the exchange rate is appreciated by more than 5.1 percent against purchasing power parity measures; $1 million generate 0.0002 percent depreciation	Contemporary
Villamizar 2015	1999–2012 (daily)	Options and discretionary purchases	Two-stage multivariate Tobit	Level: no; volatility decreases; $1 million decrease volatility by 0.005 percent	3 weeks
Ocampo and Malagón 2015	2006–13 (monthly)	All interventions (no differentiation)	OLS and VAR	Yes, in the real exchange rate, when capital controls (unremunerated reserve requirements) are in place. One standard deviation shock in the interaction produces a depreciation of 0.63 percent after 8 months	From the 6th month to the 13th month
Kuersteiner, Phillips, and Villamizar 2016	2002–12 (daily)	Volatility options	Discontinuous regressions	Put options of $180 million generate 2 percent depreciation; call options of $180 million generate 3 percent appreciation after 2 weeks and a contemporary depreciation of 0.3 percent	3 weeks 2 weeks (from day 5 to day 15)
Echavarría, Melo, and Villamizar 2017	2004–12 (daily)	Discretionary purchases and through daily auctions	Two-stage Tobit-GARCH	$1 million through daily auctions (discretionary purchases) depreciate 0.004 percent (0.001 percent)	Contemporary

Source: Authors' compilation.
Note: The table does not include Mandeng (2003), Uribe and Toro (2005), Toro and Julio (2005), and Echavarria, Vásquez, and Villamizar (2010). Mandeng (2003) analyzes only the first three call volatility auctions. Uribe and Toro (2005) follow an event study of call options to deaccumulate, and for volatility until October 2003; therefore, the analysis is contained in Echavarría and others (2014). The second author of the Toro and Julio (2005) paper, after working in Fuentes and others (2014), considers that the methodology used (ARCH) is subject to bias. Regarding the fourth paper, Echavarría, Melo, and Villamizar (2017) study a longer period with a similar method. ARCH = autoregressive conditional heteroskedasticity; EGARCHE = exponential generalized autoregressive conditional heteroskedasticity; GARCHE = generalized autoregressive conditional heteroskedasticity; OLS = ordinary least squares; SVAR = structural vector autoregression; VAR = vector autoregression.

CONCLUSION

Exchange rate flexibility is fundamental for an economy to maintain low and stable inflation and production levels close to their potential value. However, the Colombian central bank intervenes in the foreign exchange market without aiming to achieve any specific exchange rate value to (1) accumulate reserves to reduce external vulnerability and improve access conditions to foreign credit, (2) mitigate fluctuations in the exchange rate that do not clearly reflect the behavior of fundamental economic variables, and that may have an adverse impact on inflation and economic activity, and (3) provide foreign liquidity to the market to ensure the normal functioning of internal and external payments. Regarding the second motivation, the literature that has studied the central bank's intervention finds that the effect on the exchange rate is small, if any. Therefore, the probability of impacting inflation and economic activity is also small.

The central bank has used different intervention mechanisms, and it always sterilizes its foreign exchange interventions to keep the short-term interest rate aligned with the policy rate. Sterilization mechanisms are key elements for central banks under an inflation-targeting regime, allowing them to buy and sell reserves as needed without compromising the inflation target. Sterilization of purchases of reserves is costly.

The use of put options is a suitable mechanism for countries that need to accumulate reserves and that want to minimize the effect of reserve accumulation on exchange rates. Daily purchases of reserves might be more adequate when central banks want to influence the exchange rate. In the Colombian central bank's experience, daily purchases did not generate a sense that it was defending an exchange rate level, but discretionary purchases did. This occurs because with the daily purchases, the amounts of the intervention were the same regardless of the value of the currency. If a perceived exchange rate goal is judged as nonattainable by market participants, additional capital inflows may be attracted, rendering the foreign exchange intervention ineffective, possibly introducing unwarranted volatility to the exchange rate, and imposing greater costs on the central bank, especially if the latter reacts by increasing intervention.

Volatility options should be designed to provide a hedge under extreme circumstances, and not to control the normal volatility of the exchange rate. Volatility options should therefore have large thresholds and might be appropriate for countries with shallow derivatives markets. The disadvantage is that they might discourage the development of the derivatives market. Overall, the central bank used options to implement trigger rules for spot intervention (there was no underlying motive to use derivatives other than to "wire" the rule for the spot intervention). Foreign exchange swaps are the right mechanism to use when external credit lines have been closed. To decide how many reserves to buy or sell, it is useful to have an established framework, at least as a starting point for the discussion.

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CHAPTER 10

Costa Rica: Learning to Float

Rodrigo Cubero, Valerie Lankester, and Evelyn Muñoz

Costa Rica provides a case study of how a small, highly dollarized and very open emerging market economy gradually learns to float. Since 2006, Costa Rica has transitioned from a crawling peg regime to a managed float as part of the move toward an inflation-targeting regime. Yet, the central bank has exhibited fear of floating: foreign exchange intervention has remained frequent and the nominal exchange rate relatively stable amid concerns about the impact of exchange rate fluctuations on price and financial stability. To learn from Costa Rica's experience, this chapter first describes the structure of the exchange rate market and the modalities and motives of intervention. It then examines the effectiveness of intervention in changing the rate of variation or the volatility of the exchange rate during the float period by using two different methodologies over a high-frequency dataset: an event (or before-and-after) analysis and a standard econometric approach. It finds that, on balance, intervention has been effective.

INTRODUCTION

Over the past two decades, many emerging market and developing economies have modified their exchange rate regimes from some form of pegging toward greater flexibility. Monetary policy frameworks have moved from the exchange rate as a policy instrument to an ever-greater reliance on the interest rate, often in the context of adopting an inflation-targeting regime (IMF 2014; Laurens and others 2015). Yet, despite this move toward more flexible exchange rates, central banks in those countries have continued to engage frequently in foreign exchange intervention (Adler and Tovar 2011; Ostry, Gosh, and Chamon 2012; Benes and others 2013; IMF 2015).

That pattern is illustrated by the case of Costa Rica. Since 2006, the country has transitioned first from a crawling peg to a crawling band, and then to its

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current managed float, as part of its migration to an inflation-targeting regime. Since the last part of the crawling band regime in late 2013, the exchange rate has continuously floated—the exchange rate has moved away from the band limits and therefore the central bank was not forced to intervene to defend them.

Yet, under such a de facto float, the central bank has resorted to foreign exchange intervention for various purposes, including to contain excessive volatility. In fact, intervention has helped keep the exchange rate relatively stable during the float period, partly because of concerns over the effects of exchange rate fluctuations on price and financial stability, in the context of high trade and financial openness and high financial dollarization.

Costa Rica thus provides a case study of how a small, very open emerging market economy learns to float on its way to inflation targeting under significant structural constraints.

This chapter examines three main questions regarding foreign exchange intervention in Costa Rica:

- First, what are the modalities of intervention, and how do they work in practice? The chapter notes that direct foreign exchange interventions take place exclusively in the spot market, are sterilized, are typically large relative to the daily market turnover, and are decided on a discretionary basis by a committee at the Central Bank of Costa Rica. They are guided by rules that remain undisclosed and motives only announced ex post (after the intervention takes place but on the same day). Communications by the central bank also provide an indirect and often effective intervention mechanism.
- Second, what are the main motives and rationales of intervention? Three main motives exist: reserve accumulation, serving the needs of the public sector, and mitigating excessive fluctuations. In practice, however, all interventions seem intended to help stabilize the market, either by deliberately countering fluctuations or at least by avoiding exacerbating them. In effect, the central bank leans against the wind in its intervention decisions.
- Third, has intervention been effective in changing the rate of variation or the volatility of the exchange rate? To address this final question, the analysis focuses on the period since late 2013, and it uses two different empirical methodologies over the same high-frequency dataset on foreign exchange transactions: a standard econometric approach and an event (or before-and-after) analysis. It finds that, on balance, central bank intervention is effective in mitigating exchange rate fluctuations in Costa Rica.

The chapter is structured as follows: It first describes the evolution of the exchange rate regime and then reviews the structure and main features of the foreign exchange market in the country. It discusses the modalities, motives, and decision-making process of official interventions, and empirically analyzes the effectiveness of them. The final section concludes.

EVOLUTION OF THE FOREIGN EXCHANGE REGIME

Since the creation of the Central Bank of Costa Rica in 1950, the country has had four exchange rate regimes: fixed exchange rate (1950–80), crawling peg (1984–2006), crawling band (2006–15), and managed float (2015–present), with a disorganized, de facto floating regime during the debt crisis (1980–83). This section briefly examines each, as background for the analysis in the remainder of the chapter.

Fixed Exchange Rate Regime (1950–80)

Upon the establishment of the Central Bank of Costa Rica in 1950, Costa Rica maintained its prevailing (official) fixed exchange rate regime, along with a small free market and multiple exchange controls and restrictions.[1] Until the end of 1980, the peg remained stable, with only two discrete, step devaluations—in 1961, from 5.57 colones per US dollar to 6.65 colones, and in 1974, to 8.6 colones. However, severe negative external shocks and large fiscal deficits in the late 1970s led to a significant real exchange rate appreciation and eventually to an external debt moratorium and a massive loss of international reserves. The official exchange rate was devalued to 20 colones per US dollar. Unable to further withstand the pressures, however, in December 1980, the central bank allowed most transactions to take place in the interbank and parallel markets at a market exchange rate, and the fixed exchange rate regime was effectively abandoned. The colón depreciated sharply. High inflation and a deep economic contraction ensued (Edwards 1990; Rodríguez Clare and Rodríguez Echeverría 1990).

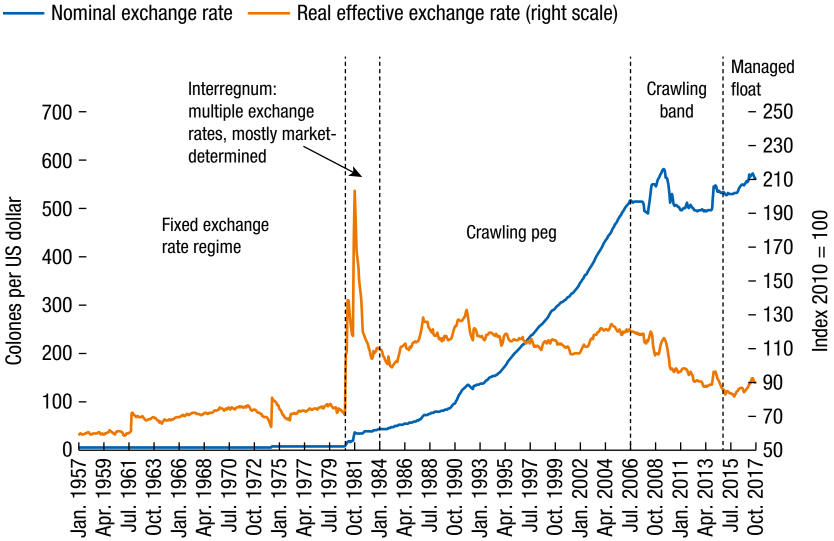
Crawling Peg (1984–2006)

A top priority after the crisis was to bring order to and reunify the exchange rate market (Delgado 2000). This was achieved toward the end of 1983. As a mechanism to ensure a smooth external adjustment, the central bank in 1984 gradually introduced a crawling peg regime, whereby the pace of adjustment of the nominal exchange rate was determined by the difference between Costa Rica's inflation rate and the weighted average of its trading partners' inflation.[2] The crawling peg helped the country maintain a stable real exchange rate—a

[1] Costa Rica's central banking history might be said to have begun in 1921, when the monopoly of money supply was granted to Banco Internacional de Costa Rica, and more formally with the banking reforms of 1936, which brought about the creation of a Mint Department at the Banco Nacional de Costa Rica. From 1921 to 1950, the country had different forms of fixed exchange rate regimes in place, including the gold standard, the dollar-gold standard, and even a currency board from 1922 to 1930. In line with the Bretton Woods agreements, the country formally adopted a fixed exchange rate regime in 1947 (Delgado 2000).

[2] The adoption of the crawling peg was an evolutionary, de facto process: no explicit central bank board decree introduced the regime. The crawling peg regime was suspended between March and July 1992, when the exchange rate was allowed to float.

Figure 10.1. Nominal and Real Effective Exchange Rates under Different Regimes, 1957–2017



Source: Central Bank of Costa Rica.
Note: The bilateral real exchange rate between Costa Rica and the United States is shown for January 1957 through November 1979. Costa Rica's consumer price index was interpolated between January 1973 and October 1974 because of data irregularities.

crucial component of its transition to an export-oriented development strategy (Figure 10.1).

However, against an open capital account (whose liberalization was completed in March 1992), the peg limited the autonomy and effectiveness of monetary policy (the "impossible trilemma"). Moreover, because of its inherent inertia and predictability, this regime (as well as the central bank's large sustained losses) led to high inflation (18.7 percent on average between 1982 and 2006), which consequently required a sustained nominal depreciation (from about 43 colones per US dollar in 1984 to about 520 colones by 2006). It also stimulated financial dollarization. This, along with an open capital account, large fiscal deficits (averaging about 2 percent of GDP in 1982–2006), and the central bank operating deficits, reduced monetary policy effectiveness to bring about price stability (Alfaro Ureña, Sánchez Wong, and Tenorio Chaves 2016).

Crawling Band (2006–15)

Explicitly acknowledging the drawbacks of the crawling peg, in October 2006 the central bank switched to a crawling band regime, with no central parity.[3] The shift was presented as a transitory strategy to allow for a gradual move toward greater exchange rate flexibility and the eventual adoption of a floating regime. This, in turn, was justified as a precondition for an eventual shift to inflation targeting, with the policy interest rate as the instrument. The rates of crawl of the band limits were set such that the band would widen over time, although the crawl parameters were modified several times, and the floor was eventually fixed, in July 2008, at C500.

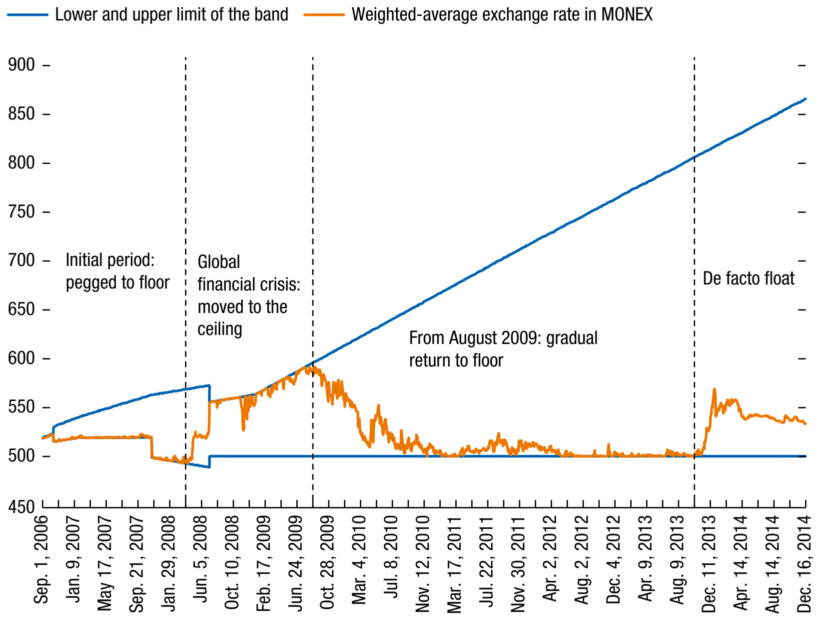
For much of the crawling band period, the exchange rate remained pegged to either end of the band (Figure 10.2). Initially, it was stuck to the floor. In 2008, with the financial shocks around the global financial crisis, it moved to the ceiling. As external conditions improved, and capital inflows returned toward the final quarter of 2009, the exchange rate moved gradually back to the floor of the band and remained there or close to it from about October 2010 to late 2013. Starting in December 2013, against expectations of US monetary policy tightening, the exchange rate moved away from the floor of the band and remained within the band (in a sort of float, although with active intraband foreign exchange intervention), until the central bank officially switched to a floating regime in January 2015.

The crawling band regime brought significant progress to the monetary policy framework (Central Bank of Costa Rica 2015; Alfaro Ureña, Sánchez Wong, and Tenorio Chaves 2016). It allowed a gradual move away from the exchange rate anchor and toward greater exchange rate flexibility, and it created the conditions for an active and meaningful use of a policy interest rate from June 2011. In addition, with on-the-band intervention centered, by definition, on buying US dollars at the floor and selling them at the ceiling, the regime helped reduce central bank financial losses (Muñoz 2012). This, in turn, along with the greater effectiveness of monetary policy, contributed to a significant reduction in inflation, despite a deteriorating fiscal situation (Figure 10.3). The scope for wider exchange rate fluctuations induced a higher perception of currency risk, helping to continue an already present trend toward lower financial dollarization: the share of foreign currency deposits went down over 2006–14, even when adjusting for the effect of exchange rate changes (Figure 10.4). The effect on credit dollarization is less clear.[4]

[3] Article 5 of the Board of the Costa Rican central bank's decision to adopt a crawling band (Session 5300–2006, October 13, 2006) states: "The crawling peg regime has contributed to maintaining relative external stability over the last two decades and allowed a successful integration of the Costa Rican economy into global markets. However, it has also generated costs and vulnerabilities to the national economy, and reduced the effectiveness of the Costa Rican central bank's monetary policy, whose primary objective is the achievement of a low and stable inflation."

[4] In 2013–14, authorities also took prudential measures to induce a decline in the degree of financial dollarization, including higher risk weights for capital adequacy purposes for loans to foreign exchange borrowers who are not naturally hedged.

Figure 10.2. MONEX Exchange Rate under the Crawling Band Regime, 2006–14



Source: Central Bank of Costa Rica.
Note: MONEX (Mercado de Monedas Extranjeras) is an organized electronic foreign exchange market provided by the Central Bank of Costa Rica (more details are provided in the "Foreign Exchange Market: Structure and Characteristics" section).

In addition, as the monetary policy framework strengthened, the crawling band regime helped reduce the exchange rate pass-through to inflation, from 0.6 at the beginning of the period to 0.2 (Rodríguez Vargas 2009; Brenes and Esquivel 2017).

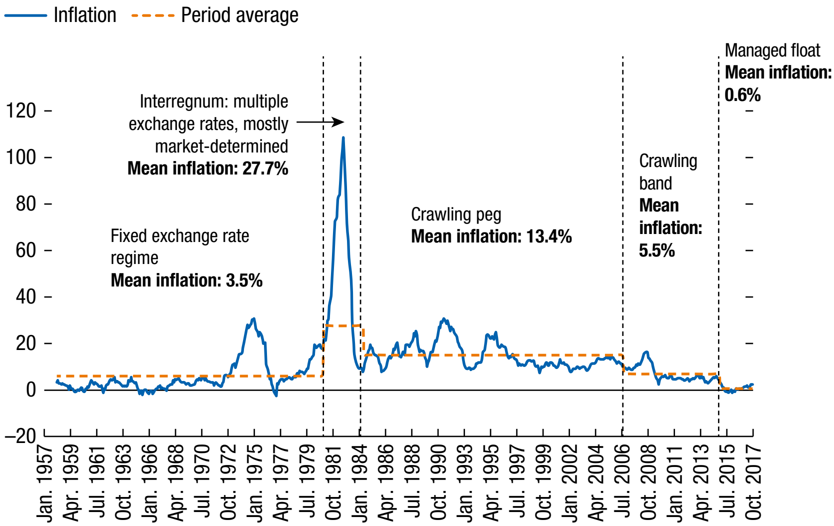
Managed Float (2015–Present)

Considering these achievements and that the exchange rate had remained away from the band limits since December 2013, the Central Bank of Costa Rica formally adopted a managed floating regime in January 2015, as a necessary step to complete the transition to inflation targeting.

Under the new regime, the central bank commits to "allow the exchange rate to be determined freely by the market, but will participate in the market to meet its own foreign currency needs and those of the non-financial public sector and, at its discretion, to prevent sharp (literally, "*violent*") fluctuations in the exchange rate" (Central Bank of Costa Rica 2015).

However, since the adoption of a de jure floating regime, the nominal exchange rate has remained relatively stable. The IMF classified Costa Rica's de facto regime as "crawl-like" in 2017 and "stabilized" during 2015 and 2016 (Table 10.1). Both categories are under the "soft peg" type. This category applies

Figure 10.3. Consumer Price Index Inflation under Different Exchange Rate Regimes, 1957–2017
(Percent)



Source: Central Bank of Costa Rica data.
Note: Costa Rica's consumer price index was interpolated between January 1973 and October 1974 because of data irregularities.

when the spot market exchange rate has remained within a margin of 2 percent for six months or longer and is not floating; that is, the exchange rate remains stable "as a result of official action."[5] We review this topic again in the section on the anatomy of official foreign exchange intervention.

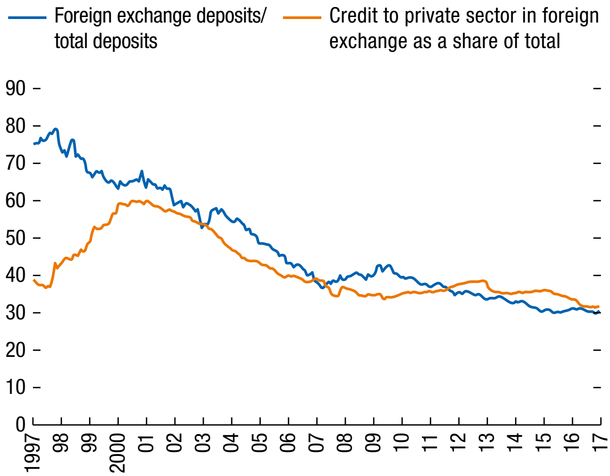
The managed float regime has furthered the transition toward inflation targeting that began in 2006 and has strengthened monetary policy.[6] In particular, the scope for greater exchange rate flexibility under the managed float (even if dampened by intervention) has allowed the use of the policy interest rate as a policy instrument.[7] Inflation has further declined and remained at or below target during this period, while inflation expectations—although sticky—have moved into the inflation target range, as shown in Figure 10.5.

[5] For specific definitions, see IMF's AREAER Database, multiple years. The IMF also classified the de facto regime as "stabilized" during 2014, when the central bank considered the exchange rate to be under a de facto managed float, because it remained within the limits of the crawling band.

[6] Muñoz (2018) provides details on this transition until the formal adoption of an inflation-targeting regime.

[7] Transmission from the policy rate to other rates in the system has been incomplete, in part because of financial dollarization and the oligopolistic structure of the financial system (Barquero and Mora 2014; Barquero and Orane 2015).

Figure 10.4. Financial Dollarization: Foreign Exchange Deposits and Credit to the Private Sector, 1997–2017
(Percent)



Source: Central Bank of Costa Rica data.
Note: To control for the effect of exchange rate changes on the local currency values of foreign exchange variables, these values are computed at the January 2014 mean exchange rate. Data shown are for December of each year.

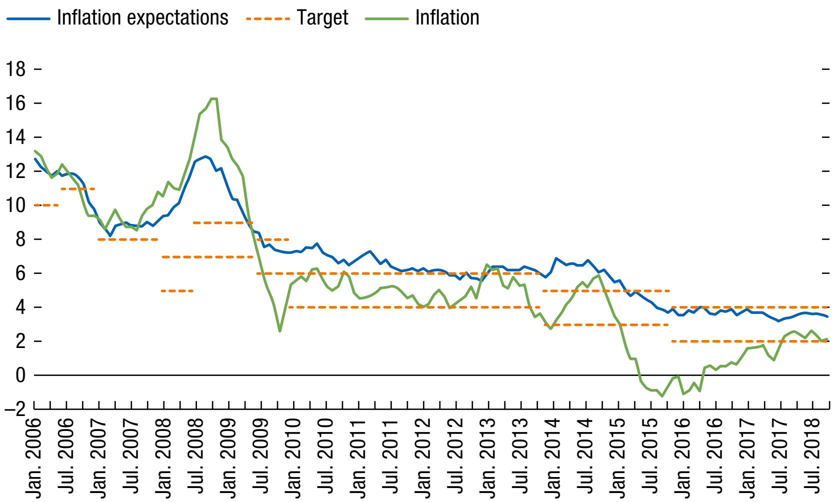
TABLE 10.1.

IMF's Classification of De Facto Exchange Rate Arrangements, 2006–17

Year	Crawling Peg	Crawling Band	Crawl-Like	Stabilized	Other Managed
2006	×				
2007		×			
2008					×
2009					×
2010					×
2011					×
2012				×	
2013					×
2014				×	
2015				×	
2016				×	
2017			×		

Source: IMF's AREAER, 2006–17.

Figure 10.5. Inflation Target, Expectations, and Observed Inflation, 2006–18
(Percent)



Source: Central Bank of Costa Rica data.

FOREIGN EXCHANGE MARKET: STRUCTURE AND CHARACTERISTICS

Foreign exchange transactions in Costa Rica take place almost entirely in the spot markets—despite the authorities' efforts to foster development of foreign exchange derivatives, the use of these instruments remains limited and largely incipient.

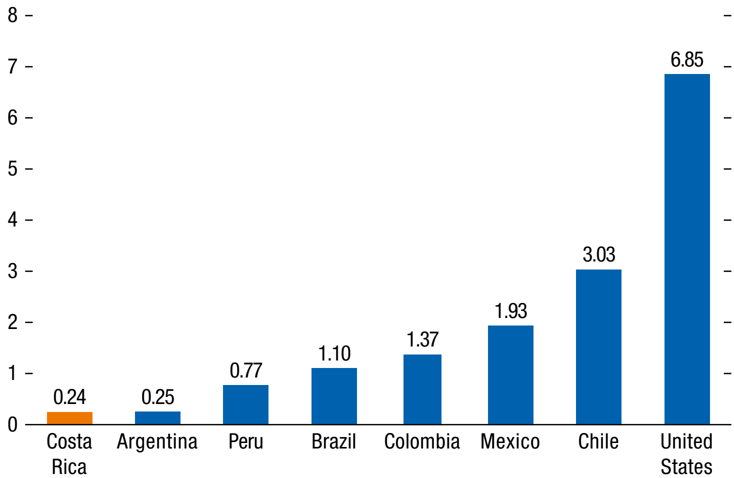
There are two main foreign exchange spot markets: over-the counter windows ("ventanillas") and an organized electronic foreign exchange market (*Mercado de Monedas Extranjeras*, known as MONEX).

Over-the-Counter Windows (*Ventanillas*)

The *ventanillas* comprise over-the-counter foreign exchange transactions between financial institutions and the public, whether they are individuals or corporations, performed through physical or electronic platforms. Smaller, nonfinancial participants in this market tend to be price takers, and they face relatively high transaction costs, with spreads of around 2 percent between sale and purchase rates.[8] While the traded amounts are generally small (90 percent are smaller than $1,000), the market accounts for about 89 percent of the total value of foreign

[8] Agents with very large transaction volumes often negotiate directly with financial intermediaries and obtain better rates. These transactions represent about 3 percent of the total, in value terms.

Figure 10.6. Over-the-Counter Daily Average Foreign Exchange Turnover, 2016
(Percent of GDP)



Sources: Central Bank of Costa Rica; and Bank for International Settlements.

exchange transactions. The average turnover in the over-the-counter market was about $141.5 million a day in 2017. This is very small by international standards (Figure 10.6).

Electronic Foreign Exchange Market (MONEX)

This is an electronic platform provided by the central bank in which the central bank itself, financial intermediaries, and any individual or corporation with registered accounts can participate.[9] To improve the price-making process, negotiating sessions have been gradually shortened, from an initial eight-and-a-half hours to three hours, at present. The minimum transaction amount is $1,000, and the cost for participants is 0.20 percent of the traded amount. Agents place their bids and offers on the electronic platform, and the transaction is completed and settled automatically in real time when a match emerges. An important feature of MONEX transactions is that they are anonymous: participants do not and cannot know the identity of the counterpart; only the central bank does.

MONEX represents only around 11 percent of the country's total foreign exchange transactions in value terms, and this share has not changed significantly

[9] MONEX started in 2006. It was initially restricted to authorized entities (mainly financial institutions). From 2009, corporations and individuals were also allowed to participate, which helped reduce concentration in MONEX as well as intermediation spreads in *ventanillas* (Central Bank of Costa Rica 2010).

TABLE 10.2.

Structure and Size of the Foreign Exchange Market, 2012–17
(Daily average turnover)

	MONEX		Over the Counter		Total
Year	Thousands of US Dollars	Percent of Total	Thousands of US Dollars	Percent of Total	Thousands of US dollars
2012	19,454	14.2	117,482	85.8	136,935
2013	17,585	12.7	120,889	87.3	138,474
2014	16,455	12.1	119,395	87.9	135,850
2015	15,270	10.9	124,656	89.1	139,926
2016	13,551	9.3	132,871	90.7	146,422
2017	17,035	10.7	141,546	89.3	158,581

Source: Central Bank of Costa Rica.
Note: MONEX (Mercado de Monedas Extranjeras) is an organized electronic foreign exchange market provided by the Central Bank of Costa Rica.

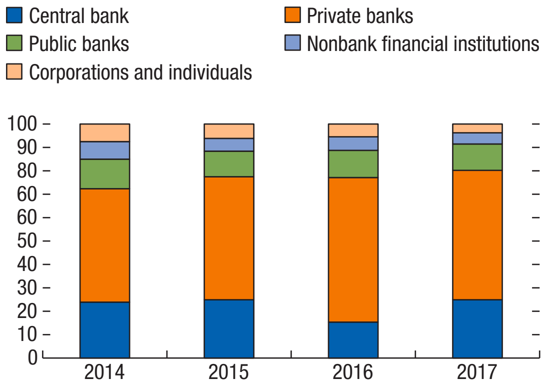
since the opening of this platform in 2006. The mean turnover value was $17 million per day in 2017 (Table 10.2). However, MONEX plays a critical role as the market in which price discovery takes place. Because financial institutions are subject to prudential limits on their net open foreign exchange positions, any excess demand or supply of foreign exchange in their over-the-counter transactions will typically be reflected in their positions in MONEX. As such, MONEX acts as the clearing and price-making channel for the country's overall foreign exchange flows, despite its small share in total transactions. It is also the market in which the central bank's interventions take place.

In 2017, there were 633 participants in the MONEX market, comprising the central bank, 4 state-owned banks, 11 private banks, 20 nonbank financial institutions (stock brokerage houses, credit unions, and nonbank intermediaries), and 597 private firms and individuals.

MONEX is characterized by a relatively high degree of concentration. The central bank accounts for about one-quarter of total turnover, but it faces powerful counterparts in MONEX (Figure 10.7). Excluding the central bank, the share of the top four participants (all private banks) in turnover was 57 percent in 2017, up from 47 percent in 2014 (Figure 10.8).[10] It is widely recognized that a few large banks wield a disproportionately large power in the foreign exchange market (see, for example, the views from different economists cited in Lizano 2018). The share of individuals and nonfinancial corporations in the value of MONEX transactions has been declining, to less than 4 percent in 2017. Deterred by moderate

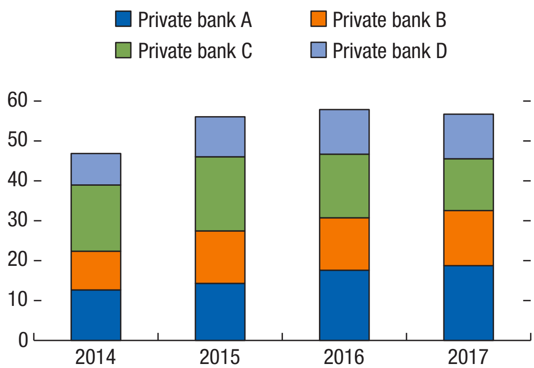
[10] The Herfindahl-Hirschmann Index for traded values in MONEX (excluding the central bank's interventions) gives a concentration figure of 1,000 for 2017, which corresponds to the threshold between low and moderate concentration. However, the index was designed for product markets, and yields low values when the largest firms have relatively equal market shares, as is the case in MONEX (19 percent, 14 percent, 13 percent, and 11 percent, for the four largest firms, respectively), instead of having one or two firms with very large shares, which is the main concern that the index addresses.

Figure 10.7. MONEX Market: Structure, by Category, 2014–17
(Percent)



Source: Central Bank of Costa Rica data.
Note: MONEX (Mercado de Monedas Extranjeras) is an organized electronic foreign exchange market provided by the Central Bank of Costa Rica.

Figure 10.8. MONEX Market: Share of Top Four Participants in Turnover, 2014–17
(Percent)



Source: Central Bank of Costa Rica data.
Note: The figure excludes the Central Bank of Costa Rica. MONEX (Mercado de Monedas Extranjeras) is an organized electronic foreign exchange market provided by the Central Bank of Costa Rica.

barriers to entry (for example, traded amounts must be multiples of $1,000, with a minimum of $1,000 per transaction; and the know-how to use the electronic platform), smaller private sector agents may prefer the over-the-counter *ventanillas*, despite their higher spreads. This creates market segmentation.

These features, along with the residual nature of MONEX (to which surplus or deficit positions in the over-the-counter market are shifted by financial institutions for clearing), create a risk that sudden shifts in overall foreign exchange flows or in sentiment by large players may inundate the MONEX market, fuel destabilizing speculation, and lead to excessive price volatility.

ANATOMY OF OFFICIAL FOREIGN EXCHANGE INTERVENTION

This section studies the procedural and institutional aspects of foreign exchange intervention by the Central Bank of Costa Rica: the process for making intervention decisions, the modalities of intervention, the motives, and communications about intervention. The analysis focuses on interventions since December 2013; that is, in the latter part of the crawling band regime, when the exchange rate was not on the limits of the band and under the current managed floating regime. Interventions under any variant of a fixed exchange rate regime (including when the exchange rate was pegged to the band limits) lack analytical interest: they are not discretionary, but rather forced by the very nature of the regime, because the central bank is committed to buying or selling all foreign exchange needed to maintain the exchange rate at the given rate.

The analysis in this section is based on daily intervention data. Of course, the central bank can conduct multiple discrete interventions within one day, but these are all aggregated into daily observations for the purposes of this section.

Modalities of Intervention

As noted, official central bank intervention in Costa Rica takes place entirely in the MONEX (spot) market. There are no well-developed derivatives markets or derivative instruments that the central bank can use for intervention.

Between December 13, 2013, and March 9, 2018, there were 1,077 trading sessions in MONEX. During this period, central bank interventions in MONEX (sales and purchases) amounted to $6.5 million per day, on average, over all days of session, and to a mean of $8.8 million per day for the days when central bank interventions took place. The latter were 789 out of the 1,077 days (and because some sessions had interventions for different motives, the period comprised 832 daily interventions). The average daily value of transactions in MONEX for the period was $15.6 million; thus central bank interventions account for 57 percent of total MONEX turnover on days when interventions take place. This is clearly significant in value terms.

With the interest rate as policy instrument, all foreign exchange interventions must be sterilized to isolate the monetary effect of intervention and safeguard the independence and effectiveness of the policy rate (see Ostry, Gosh, and Chamon 2012; Benes and others 2013; and chapter 2 of this book). In the case of Costa Rica, all foreign exchange interventions are sterilized through daily liquidity auctions. These operations are approved daily by a committee (different from the market committee making intervention decisions), and their magnitude is determined depending on, among other factors, the effects of central bank intervention on the monetary base. As a result, during periods of sustained foreign exchange purchases (sales) by the central bank, its domestic liabilities increase (decrease) because of sterilization operations, in line with its net international reserves.

In addition to direct interventions through participation in MONEX, the central bank conducts more subtle or indirect intervention through two other mechanisms: (1) the decision not to intervene in MONEX to replenish reserves after fulfilling the foreign exchange needs of the public sector; and (2) the communications with the public to influence exchange rate expectations.

Decision-Making Process

Intervention decisions are guided by a general framework approved by the central bank's Board of Directors (Figure 10.9).

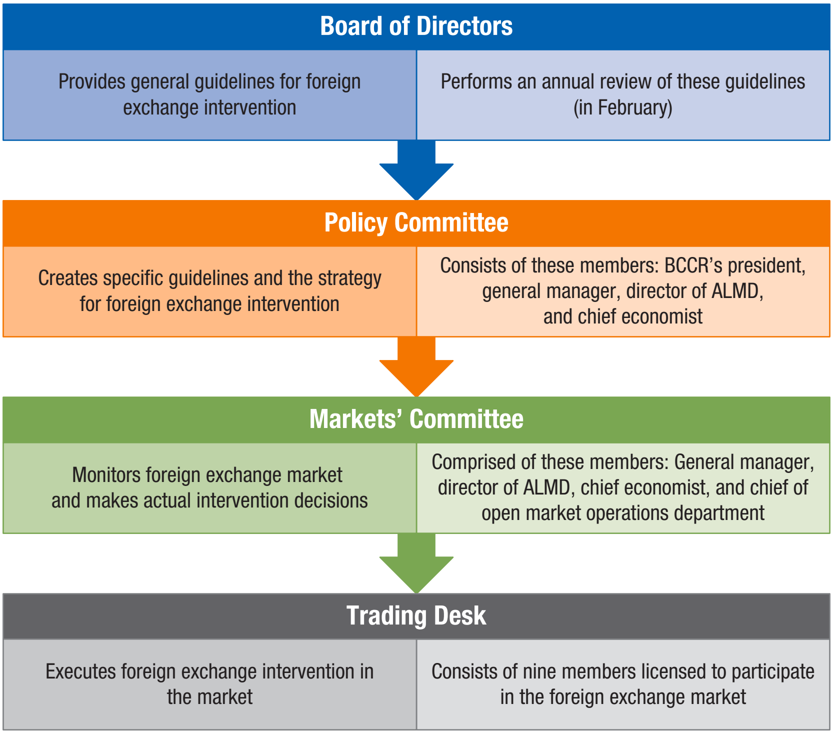
In this framework, the strategy and specific criteria for intervention are defined by the Policy Committee, comprised of four members: the central bank president, the general manager, the chief economist, and the director of the Asset and Liability Management Division. A quorum is reached with the president and two other members of the committee, and decisions are made by simple majority. In a tie, the president's vote counts twice.

The committee meets every Monday afternoon and several times per week, depending on the circumstances. In times of stress or high volatility, the committee meets every day, and sometimes even several times per day. The frequency of meetings is determined by daily information from staff, who continuously monitor foreign exchange market behavior, including developments in prices (for instance, trend and volatility of the exchange rate), trading volumes, and the overall deficit or surplus of foreign exchange in the market, and whether it is consistent with identified seasonal patterns. To back up this analysis, a model is used to predict foreign exchange volumes and trends. If staff identify significant movements that are unusual (once seasonality factors are considered) or not justified by fundamentals, it proposes a meeting of the Markets Committee to decide whether stabilization interventions are required.

The Markets Committee makes actual intervention decisions (timing and magnitude), and comprises the general manager, the chief economist, the director of the Asset and Liability Management Division, and the chief of the open market operations department. The decisions are made based on the general framework provided by the central bank board, the criteria and strategy set by the Policy Committee, and the information provided continuously by staff.

Any intervention decided by the Markets Committee will be executed by the trading desks in the Asset and Liability Management Division. They have little

Figure 10.9. Decision Makers for the Central Bank of Costa Rica's Foreign Exchange Intervention



Source: Authors, based on information from the Central Bank of Costa Rica.
Note: ALMD = Assets and Liabilities Management Division; BCCR = Central Bank of Costa Rica.

room for discretion, given that the relevant parameters of intervention (including amounts, timing, and total available budget) will have been set by the committee.

Intervention Motives

The central bank participates in the foreign exchange market for three main, publicly articulated reasons (Central Bank of Costa Rica 2015):

- To "satisfy its own foreign exchange needs"
- To "fulfill the foreign exchange needs of the nonfinancial public sector"
- To "prevent violent exchange rate fluctuations"[11]

This subsection looks at each one of these in turn.

[11] Under the crawling band regime, a fourth motive for the central bank to intervene was to defend the limits of the band. As discussed, this type of intervention is not considered in the analysis.

TABLE 10.3.

Central Bank of Costa Rica's Recent International Reserve Accumulation Programs

Program	Expected Implementation Period	Actual Implementation Period	Expected Amount (in $ million)	Actual Amount (in $ million)
I	Sep. 2010–Dec. 2011	Sep. 6, 2010–Apr. 18, 2011	600.0	600.0
II	Feb. 2012–Dec. 2013	Mar. 12, 2012–Jan. 11, 2013	1,500.0	1,500.0
III	Aug. 2014–Dec. 2015	Oct. 21, 2014–Jul. 27, 2015	250.0	250.0
IV	Feb. 2015–Dec. 2016	Feb. 27, 2015–Dec. 31, 2016	800.0	698.1
V	Jan. 2016–Dec. 2017		1,000.0	0.0
Total			**4,150.0**	**3,048.0**

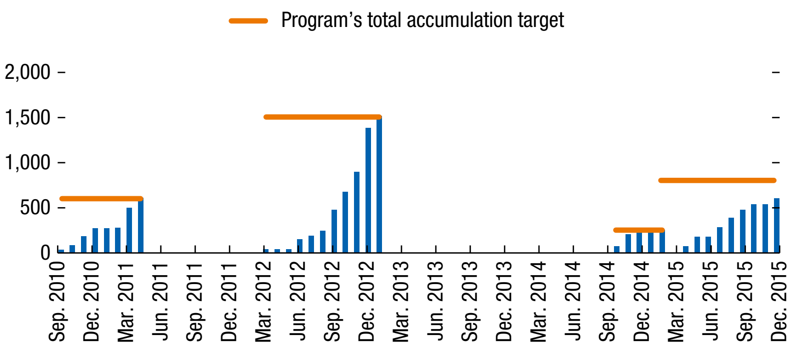
Source: Central Bank of Costa Rica data.

Intervention to Satisfy the Central Bank's Foreign Exchange Needs

The central bank needs to accumulate reserves for precautionary purposes. To fulfill this need, starting in 2010, the central bank's board approved and publicly announced five net international reserve accumulation programs (Table 10.3 and Figure 10.10). The announcements included the expected accumulation amounts and the time window for implementation, but they did not dictate the specific timing or magnitude for each intervention, which was left to the central bank's discretion. The central bank board, however, prescribed that foreign exchange purchases for reserve accumulation be undertaken when there is a foreign exchange surplus, to prevent creating excessive volatility in the market. Against increased instability in the foreign exchange market, the fourth program was not completed, and the fifth was not implemented at all. There is no active reserve accumulation program at present.

The stated objective of these programs has been to strengthen Costa Rica's net international reserve position on several adequacy metrics, such as GDP,

Figure 10.10. Central Bank of Costa Rica's Reserve Accumulation Programs: Cumulative Effect on Net International Reserves, 2010–15
(Thousands of US dollars)



Source: Central Bank of Costa Rica data.

short-term external debt, total external debt, monetary aggregates, or months of imports, sometimes using relevant comparator countries as a benchmark. The central bank has often defined its desired reserves as a range, typically as a ratio to GDP. For example, in 2006, it established a target minimum net international reserves at 11 percent of GDP (Laverde and Muñoz Salas 2006). More recently, it announced a target range for a net international reserve of 11–15 percent of GDP, including in its Strategic Plan for 2015–2019 (Central Bank of Costa Rica 2016). Some of the program announcements also indicated that the purchases should be made at the lowest price possible (that is, when the domestic currency has appreciated), and should balance between costs (inflation, exchange rate, and interest rates) and benefits (stronger external position).

Reserve accumulation is, of course, not discretionary during periods when the exchange rate is pegged to the bottom of the crawling band. This made Programs I and II somewhat redundant: Accumulation had to occur under the rules of the regime, regardless of whether a deliberate program existed. Programs to guide reserve-boosting foreign exchange purchases are more relevant when the exchange rate is fluctuating within a band or floating, such as for Programs III through V in the period after the end of 2013.

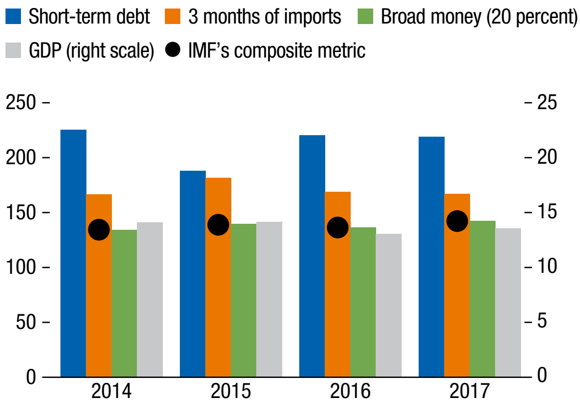
Looking at standard reserve adequacy metrics, including those cited by the central bank, Costa Rica's net international reserve position has been strong since 2014; it comfortably exceeds commonly used thresholds, and it is well within the central bank's target adequacy range of 11–15 percent of GDP (Figure 10.11). This may, in part, explain why reserve accumulation programs have been modest in size and why their implementation has not always been completed during the past few years.

Figure 10.12 shows central bank intervention for reserve accumulation purchases (by definition, they are all foreign exchange purchases, shown as positive bars), as well as the evolution of the weighted-average MONEX exchange rate. As the figure suggests, these reserve accumulation programs have been executed during times when the exchange rate was stable or amid appreciation pressures, to help stabilize the market. The mean value of these interventions was $8.9 million per day from late December 2013 through February 2018, which is sizable compared with a mean total turnover in MONEX of $15.6 million per day during the period. Also, the intervention amounts for this motive have tended to be more uniform (a lower standard deviation) than for the other two motives.

Intervention to Fulfill the Foreign Exchange Needs of the Nonfinancial Public Sector

In Costa Rica, the nonfinancial public sector is a net demander of foreign exchange. While some public sector entities supply foreign currency, others are among the country's largest importers, including the state-owned hydrocarbons and electricity and telecommunications enterprises (RECOPE and ICE, respectively). Until 2014, large nonfinancial public sector agencies participated in MONEX to meet their foreign exchange needs directly. Despite central bank

Figure 10.11. Standard Reserve Adequacy Metrics, 2014–17
(Percent)



Sources: Central Bank of Costa Rica; and the IMF.
Note: For the ratio to GDP, there is no conventional threshold; for all other metrics, the standard threshold is 100.

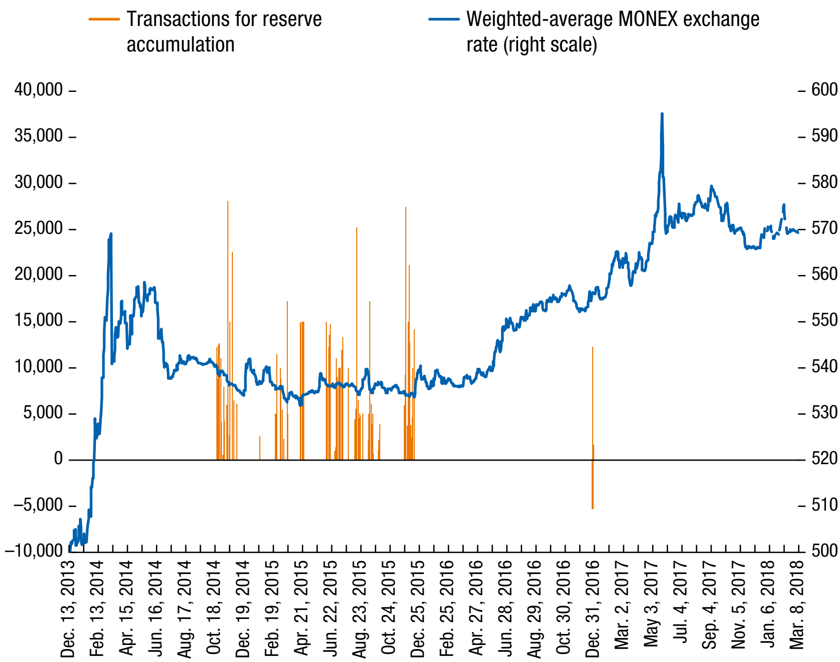
attempts to schedule and regulate their purchases, occasionally these entities placed disproportionately large demands relative to MONEX's thin trading volumes, which have potentially destabilizing effects for price formation.

To stop this source of volatility, in June 2014, the central bank decided to supply the nonfinancial public sector foreign exchange needs directly, using its net international reserves. It then resorts to MONEX, at its own pace and discretion, to replenish the reserve position. Or it purchases public sector agencies' foreign exchange surpluses, when they occur, and might, on occasion, sell them in MONEX. The timing of these interventions is guided by market conditions, including seasonal factors, which the interventions help offset.

Figure 10.13 shows the central bank's participation in MONEX for this motive. It is, by far, the most frequent type of intervention: 534 daily events of a total of 832 during the period of analysis. The figure shows that most cases were purchases; only 11 were sales. The mean value for central bank purchase interventions for this motive was $7.8 million per day from late December 2013 through February 2018, about half the mean daily turnover in MONEX.

As the figure illustrates, foreign exchange purchases to meet the needs of the nonfinancial public sector have taken place at times when the domestic currency's exchange rate is either stable or appreciating. However, amid depreciation pressures in the market, this type of intervention is postponed. The absence of participation by the central bank may thus be interpreted as an intervention by omission to stem the depreciation pressures. Lizano (2018) makes this case. On the other hand, the central bank's sporadic sales in MONEX because of transactions

Figure 10.12. Central Bank of Costa Rica's Foreign Exchange Intervention to Accumulate Reserves, 2013–18
(Thousands of US dollars, left scale; colones per US dollar, right scale)



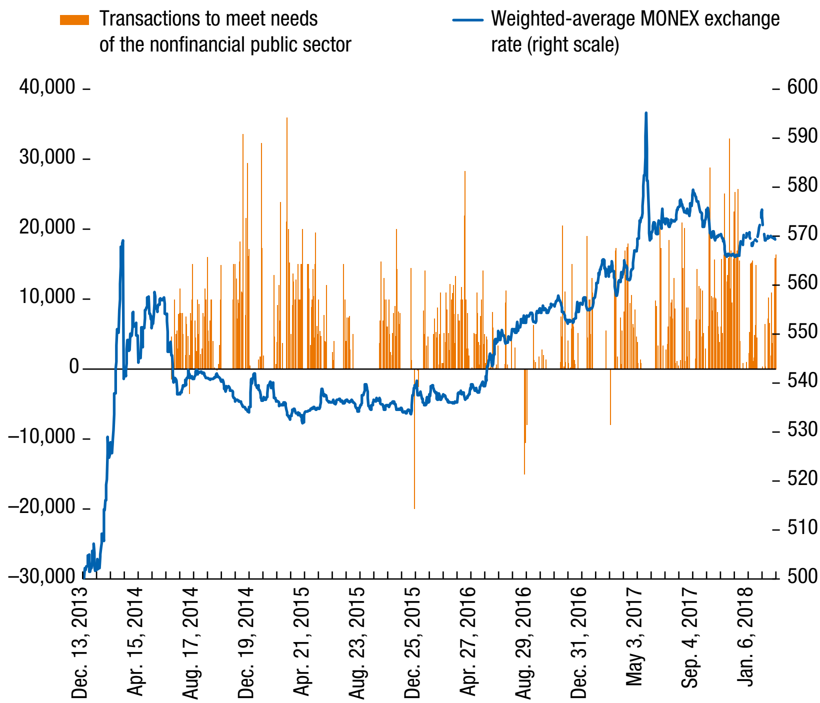
Source: Central Bank of Costa Rica data.
Note: The figure presents data collected daily. MONEX (Mercado de Monedas Extranjeras) is an organized electronic foreign exchange market provided by the Central Bank of Costa Rica.

with the nonfinancial public sector have taken place when the exchange rate was depreciating.

Therefore, in practice, discretion on the timing and magnitude of MONEX transactions to compensate for the net international reserve effects of fulfilling the nonfinancial public sector's foreign exchange needs allows the central bank to wait until market conditions are favorable to conduct these operations: purchases when there are foreign exchange surpluses and appreciation pressures and sales when the opposite occurs. The intervention amounts for these purposes are also typically smaller and more homogenous in size, to avoid disrupting the market.[12] Thus, participation for this motive seems to have stabilization purposes, as in the case of interventions for reserve accumulation. The implication is that the central bank is allowing its net international reserve position to become more volatile in the short run to accommodate its implicit foreign exchange market stabilization decisions.

[12] For example, the mean and standard deviation of daily purchases for this motive were \$7.8 million and \$6.3 million, compared with \$9.9 million and \$11.8 million, respectively, for foreign exchange sales for stabilization.

Figure 10.13. Central Bank of Costa Rica's Foreign Exchange Interventions to Fulfill Nonfinancial Public Sector Needs, 2013–18
(Thousands of US dollars, left scale; colones per US dollar, right scale)



Source: Central Bank of Costa Rica data.
Note: The figure presents data collected daily. MONEX (Mercado de Monedas Extranjeras) is an organized electronic foreign exchange market provided by the Central Bank of Costa Rica.

Intervention for Stabilization and Intervention Rules

The central bank's third motive for intervention is to prevent extreme or "violent" fluctuations in the exchange rate. On the basis of its own communications (see, for instance, Central Bank of Costa Rica (2017a and 2017b), the central bank has two main concerns regarding the effect of sharp exchange rate fluctuations:

- Financial stability: While the degree of dollarization of the financial system has moderated over the past decade, it remains high (Figure 10.14). Furthermore, it is estimated that about 71 percent of foreign exchange denominated credit to the private sector has been granted to households or corporations that do not earn foreign exchange (Central Bank of Costa Rica 2017c). These balance sheet mismatches mean that a sharp depreciation could lead to the materialization of large foreign exchange–induced credit risks in the financial system.
- Price stability: Although the exchange rate pass-through coefficient has declined, as argued earlier, it is still high, and the Central Bank of Costa

Rica has expressed concern that excessive foreign exchange volatility might affect exchange rate expectations, and thereby, expected and actual inflation.

These concerns create, and help explain, a clear antidepreciation bias in the central bank's stabilization interventions. Moreover, because interventions for the other two motives are mostly purchases, they cannot directly help to stem a depreciation (except, implicitly, by postponing the purchases until the pressures have ended or eased). Stabilization interventions as sales are thus the central bank's only direct, active intervention tool to contain strong depreciation pressures and the stability risks associated with them.

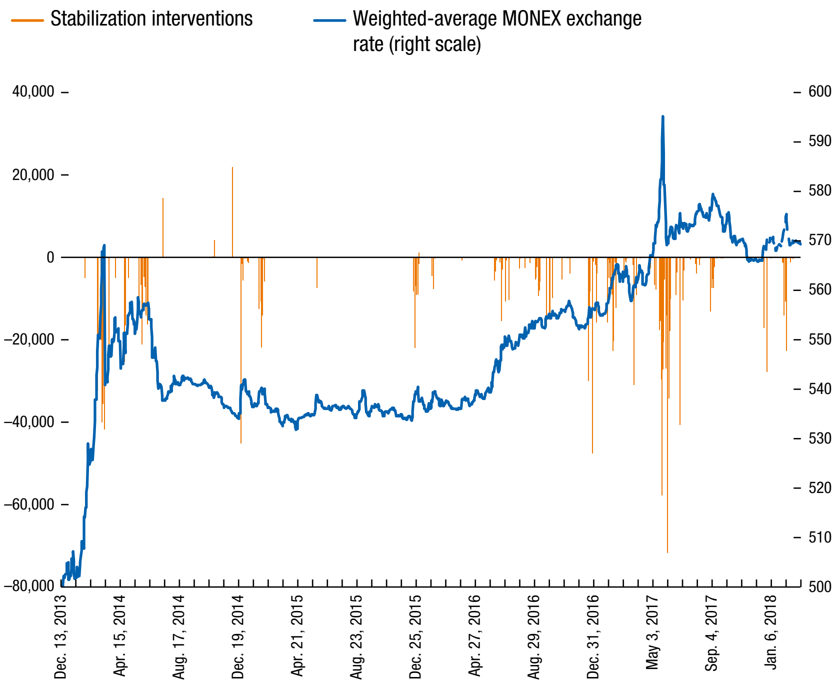
Figure 10.14 confirms this. It shows the interventions in MONEX for stabilization purposes. As the figure illustrates, the majority of such interventions have been foreign exchange sales, and some very large (with a mean of $9.9 million per day on days when they occur). This includes sales of $71.7 million on June 21, 2017, the largest daily intervention of any type in the period of analysis, and more than four times larger in size than the average total daily foreign exchange turnover in MONEX. By contrast, only six isolated foreign exchange purchases have been made for stabilization, most amid strong appreciation trends in 2014.

To guide the implementation of foreign exchange interventions for stabilization, the central bank board has defined two intervention rules (Central Bank of Costa Rica 2015), whose specific parameters are kept confidential, as explained in the next section:

- An intraday rule: Adopted early in the crawling band regime period, this rule is triggered by excessive or "violent" exchange rate volatility within the same negotiation day in MONEX.[13] The rule defines excessive fluctuation, with the volatility on the previous several days as a benchmark (with the number of days decided by the Markets Committee). The purpose of the resulting intervention is precisely to mitigate such sharp fluctuations, but not to affect the trend of the exchange rate. If the rule is triggered, the central bank assesses first whether the large intraday exchange rate movements can be explained by fundamentals (for example, changes in interest rate differentials or in the terms of trade) or are consistent with seasonal events. If not, the Markets Committee might decide to intervene, using its discretion to determine the details of the intervention within the broad contours defined by the central bank board. There is an assigned budget for this type of intervention, with daily and annual limits. Once this budget is exhausted, price adjustments may be allowed.
- An interday rule: This rule was introduced in March 2014, following several weeks of sustained, sharp depreciation pressures (Box 10.1). This episode made it clear that a rule based on intraday volatility might not be sufficient to stem persistent pressures. This rule aims to set the criteria for intervention to prevent sustained "deviations of the exchange rate from the level consis-

[13] The objectives and broad criteria for this rule were explained in detail in Central Bank of Costa Rica 2014b.

Figure 10.14. Central Bank of Costa Rica's Foreign Exchange Stabilization Interventions, 2013–18
(Colones per US dollar)



Source: Central Bank of Costa Rica data.
Note: The figure presents data collected daily. MONEX (Mercado de Monedas Extranjeras) is an organized electronic foreign exchange market provided by the Central Bank of Costa Rica.

tent with medium- and long-term economic fundamentals" (Central Bank of Costa Rica 2014c, 2015). Instead of focusing on the intraday volatility relative to the last few days' volatility, the interday rule is based on the cumulative deviations (over several days or weeks) of the exchange rate from the long-term path predicted by its fundamentals. This is determined based on an equilibrium real effective exchange rate framework, with a confidence band. If the exchange rate is deemed misaligned (that is, outside the confidence bounds), the rule may be triggered. This rule would entail interventions that involve much larger amounts, and that last for longer (several days or weeks) than those triggered by the intraday rule.

The interday rule was triggered for the first time in May 2017, after another episode of sustained sharp depreciation (Box 10.1). Between May 16 and July 7, 2017, the central bank deployed $477 million in foreign exchange sales (around 7 percent of the stock of international reserves at the beginning of the episode) to withstand the pressures. These started abating in July 2017.

In its official communications the central bank indicates that, under its managed floating regime, it does not have a commitment to a particular level or range for the exchange rate, the interday rule does suggest a concern with keeping the nominal exchange rate at a level consistent with real effective exchange rate fundamentals (allowing for a confidence band around it).[14] That level, of course, will vary continuously, but the concern remains about a (moving) target level or, considering the confidence interval, a target range. Therefore, the articulation of the intraday and interday rules in official documents makes it possible to conclude that the central bank's intervention for stabilization purposes attempts to affect both the level (insofar as it is deemed inconsistent with fundamentals) and the volatility (insofar as it is deemed "violent" or excessive) of the exchange rate.

The Stabilizing Role of Official Foreign Exchange Intervention

It could be argued that, in analyzing intervention as an instrument of monetary and exchange rate policy, the interventions that matter are those conducted for exchange rate stabilization, not those aimed at accumulating reserves or satisfying the needs of the nonfinancial public sector, which are motivations that lie far from exchange rate policy. However, as argued earlier, interventions for all three motives, in practice, share a stabilizing role in Costa Rica. First, the timing and magnitude of interventions to satisfy the central bank's or the nonfinancial public sector's needs are discretionary for the central bank and chosen according to market circumstances. They are therefore unlikely to be used in a way that might contribute to a destabilizing trend. On the contrary, the specifics of these interventions, or even the lack of intervention, seem motivated by a desire to reduce volatility or unwanted fluctuations in the exchange rate. The central bank has publicly recognized this (see, for example, Central Bank of Costa Rica 2014b). Second, all three types of intervention take place in an (ex ante) anonymous, unannounced fashion on MONEX (the intervention information is published only at the end of the trading session). Therefore, from the perspective of market participants, they are observationally equivalent.

Foreign Exchange Intervention: Transparency and Communication

Official foreign exchange intervention in Costa Rica is subject to a mixed regime in terms of transparency. On the one hand, the central bank board decided that the intervention rules must be kept strictly confidential. Only a handful of high-level officials have access to these rules, and any disclosure is considered a serious fault subject to administrative and criminal liabilities. The policy of confidentiality has been justified on the argument that the small size of the domestic foreign exchange market and its high degree of concentration entail a risk that some large actors may use informational advantages about the rules to obtain

[14] See, for instance, Central Bank of Costa Rica 2015 (http://www.bccr.fi.cr/politica_cambiaria).

excessive profits, to the detriment of smaller agents or the central bank's international reserves. The confidentiality of the intervention rules was upheld by the Constitutional Chamber of the Supreme Court of Justice.[15] Moreover, contrary to other central banks (see chapter 3 of this book), the central bank does not disclose the motives, timing, or magnitude of its interventions ex ante, not even for interventions with the purpose of accumulating reserves or meeting the needs of the nonfinancial public sector.

On the side of transparency, however, the central bank publishes very detailed data on its interventions ex post, at the end of each MONEX session. Therefore, the public has full access to data on official intervention patterns up to the day before. Moreover, the central bank has complemented its intervention policies with press releases to explain the purposes of its participation in MONEX and to try to influence expectations, particularly during periods of market stress. Box 10.1 summarizes the experience with three episodes, which suggest that communications may have helped stabilize the exchange rate.

In this sense, communications themselves may be an additional intervention tool (just like, as argued earlier, the omission to intervene to meet the needs of the central bank of Costa Rica, or the nonfinancial public sector may itself be a form of intervention).

INTERVENTION EFFECTIVENESS: EMPIRICAL ANALYSIS

This section analyzes the effectiveness of foreign exchange intervention in the period from December 2013 through February 2018, when the exchange rate was in a de facto float, and all official intervention was therefore discretionary (rather than mandated by the need to defend the limits of the band). The section begins with a discussion of the framework for assessing effectiveness, continues with a brief description of the data used, and then presents the methodology and results on the effectiveness of intervention on the variation rates and volatility of the exchange rate, for two different empirical approaches: an event analysis and an econometric analysis.

Empirically Assessing the Effectiveness of Intervention in Costa Rica: A Framework

In theory, sterilized foreign exchange intervention may affect the exchange rate through portfolio balance (relative supplies of domestic and foreign currency assets) and signaling (market expectations) channels.[16] However, empirical analyses of the effectiveness of intervention face inherent endogeneity problems:

[15] Vote 2014–00–7938 of June 6, 2014.

[16] See the brief review in Chapter 2 of this book. For a comprehensive survey of the earlier literature, see Sarno and Taylor (2002).

Box 10.1. Central Bank Communications on Foreign Exchange Intervention Amid Market Stress: Three Episodes

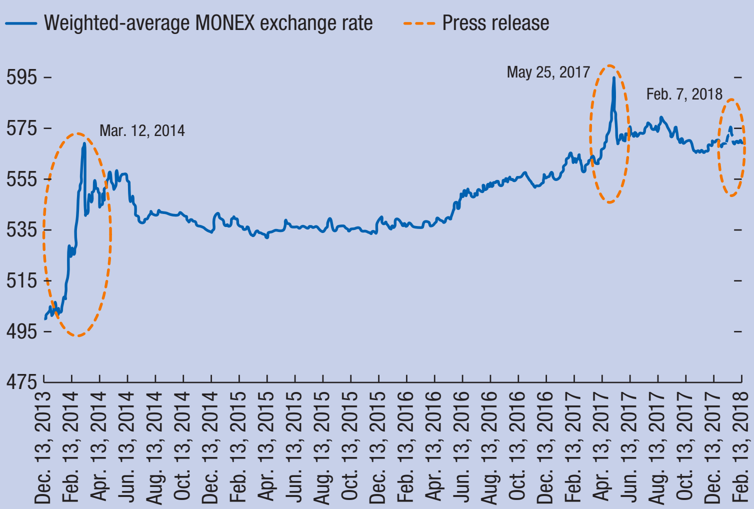
January–March 2014:

Following days of sustained depreciation pressures, the central bank issued a press release in January 2014 (Central Bank of Costa Rica 2014a) explaining that it had decided to intervene the day before to stabilize the market in light of what it considered "excessive" volatility in the exchange rate market, following announcements by the US Federal Reserve on a future tightening of policy. The central bank issued another release in February 2014, explaining in detail the logic and mechanics of its intraday intervention rule (Central Bank of Costa Rica 2014b). Pressures continued: The average exchange rate on MONEX moved from C501.8 per US dollar on January 9 to C569.1 on March 11 (a 13.4 percent depreciation). On March 12, it announced and justified the introduction of a new, interday rule (Central Bank of Costa Rica 2014c). Markets reacted immediately: The exchange rate strengthened by over C25 (4.5 percent) from March 12 to March 13. The central bank continued to issue releases that month and in April, and although pressures resumed somewhat, they remained contained.

April–May 2017:

Following sharp depreciation pressures, the central bank issued a press release on May 22, 2017 (Central Bank of Costa Rica 2017a) explaining its interpretation of foreign exchange market developments and announced that it had resorted to intraday interventions to contain volatility. It also explained that, in its view, the real exchange rate was not misaligned. Foreign exchange interventions were complemented by a significant hike in the policy rate. However, markets remained unsettled, with the average MONEX exchange rate

Figure 10.1.1. MONEX Weighted-Average Exchange Rate, 2013–18
(Colones per US dollar)



Source: Central Bank of Costa Rica data.
Note: MONEX (Mercado de Monedas Extranjeras) is an organized electronic foreign exchange market provided by the Central Bank of Costa Rica.

Box 10.1. Central Bank Communications on Foreign Exchange Intervention Amid Market Stress: Three Episodes (*continued*)

increasing from C573.8 per US dollar to C595.3 (3.8 percent) in just eight sessions between May 14 and May 24, and by over C9.0 (1.5 percent) in the two days up to May 24. As a result, on May 25 the central bank issued a new press release (Central Bank of Costa Rica 2017b), stating that the recent evolution of the exchange rate was not consistent with fundamentals, and it announced that it had decided to trigger its interday intervention rule for the first time and to dedicate a budget of up to $1 billion to stem the pressures. This reassured the markets, and the exchange rate started strengthening that same day.

January–February 2018:

Between January 29 and February 7, 2018, the exchange rate depreciated by about 1.1 percent. The central bank issued a press release on February 7 (Central Bank of Costa Rica 2018) indicating that the recent movements were not consistent with fundamentals, and it warned that similar abrupt depreciations in the past (including those in 2014 and 2017) were followed by equally sharp appreciations. Market pressures eased starting the next day.

interventions themselves are motivated by exchange rate developments. Failing to account for this endogeneity when central banks lean against the wind biases the coefficients toward zero (Kearns and Rigobón 2005; and Chapter 4 of this book). One approach to address this issue is to use high-frequency data to help isolate the intervention variable from contemporaneous exchange rate developments (Payne and Vitale 2003; Benes and others 2013). It also allows the analysis to abstract from other factors, potentially driving the exchange rate over longer-term horizons. This chapter adopts this approach by exploiting a second-by-second dataset for MONEX trades, and it applies the two empirical methodologies referred to earlier.

Effectiveness must be assessed relative to the central bank's purported objectives for intervention. As described earlier, the central bank has three distinct motives for its foreign exchange intervention. In practice, however, all three are oriented toward reducing (or at least to avoid exacerbating) excessive fluctuations in the exchange rate. In line with this, the analysis in this section focuses on the effect of intervention, on the rate of variation, and on the volatility of the exchange rate. These two—growth rates and volatility—are alternative, but not equivalent, measures of fluctuations. While the rate of variation is signed, volatility measures are not. Using variation rates allows us to assess whether interventions affect the exchange rate in a specific direction—purchases would be expected to have a positive (depreciation) effect on variation rates, and sales a negative (appreciation) effect. By contrast, the effect of any intervention, whether a purchase or a sale, on volatility would be expected to be negative. Variation rates also allow us to assess how effective interventions are in containing deviations from long-run fundamentals, which is, as explained earlier, a further motive for central bank interventions for stabilization. Moreover, variation rates can capture a deceleration of an appreciation or depreciation process as a result of an intervention, whereas using exchange rate levels as a dependent variable may lead to finding a "wrong" sign in these cases (see Chapter 4 of this book).

There has only been one published empirical study of the effectiveness of foreign exchange intervention in Costa Rica: Espinoza and Valerio (2016). Using a generalized autoregressive conditional heteroskedasticity (GARCH) analysis on daily data for the period January 2014 through April 2015, they find that interventions have a positive, but very small, effect on the level of the exchange rate and a negative effect on (conditional) volatility. In addition, a chart in a study by the Organisation for Economic Co-operation and Development (OECD) shows that, in the first year of the managed float period, interventions reduced the volatility of the exchange rate in the three-hour period after the intervention, compared with the three hours before the intervention (OECD 2016).

The empirical analysis in this chapter complements and updates Espinoza and Valerio (2016) and OECD (2016) in a number of dimensions: (1) it covers a much longer sample period (through early 2018); (2) it includes a broader analysis of the effectiveness of intervention, which separates intervention events and amounts, and aggregates intervention from purchases and sales; (3) it uses different empirical approaches; and (4) it adds a number of robustness tests. Moreover, contrary to Espinoza and Valerio (2016), who use daily data, the empirical analysis in this chapter is based on high-frequency data, which can deal with simultaneity problems.

Data and Key Variables

The empirical analysis focuses on a high-frequency dataset of MONEX trades, for the period December 13, 2013, through February 28, 2017. For each trade, it includes information on amount, price (exchange rate), and parties involved.[17]

The original dataset contains second-by-second, transaction-level data, with a total of 200,000 observations. To make the time frame more meaningful for empirically assessing the effectiveness of intervention, the data are aggregated into 15-minute intervals, following Payne and Vitale (2003). This yields a total of 28,940 observations.

The main variables used for the analysis are two measures of the exchange rate (its rate of variation and its volatility) and several indicators of intervention, including intervention dummies and amounts, whether aggregate or broken down into purchases and sales (see Table 10.4).

Methodology

To assess empirically the effectiveness of foreign exchange interventions, this chapter uses two different methods: an event analysis and an econometric

[17] To maintain the confidentiality of the information at the transaction level, all the estimations in this chapter were performed at the central bank.

TABLE 10.4.

Definition of Variables

Variable	Definition
r	Rate of variation (or *rate of return*, as it is frequently referred to in the finance literature) of the colones/US dollar exchange rate over 15 minutes.
r-an	Annualized *r*, expressed in basis points.[1] This is used for regression analysis to make the coefficients easier to interpret.
r-sq	Squared returns, estimated as $rsq = \sqrt{\ln(r^2+1)}$, as a first measure of volatility.
r-dev	Standard deviation of the exchange rate level, defined over alternative windows (15 minutes, 60 minutes), as another measure of volatility.
I	Signed intervention indicator dummy, which, for any 15-minute interval, takes the value of 1 if the central bank purchased US dollars in that interval, −1 if it sold US dollars, and 0 otherwise.[2]
P	Official foreign exchange purchase indicator, which, for any 15-minute interval, takes the value of 1 if the central bank purchased US dollars in that interval, and 0 otherwise.
S	Official foreign exchange sale indicator, which, for any 15-minute interval, takes the value of 1 if the central bank sold US dollars in that interval, and 0 otherwise.
X	Central bank foreign exchange intervention amounts, in millions of US dollars, where purchases take a positive sign and sales a negative sign.
XP	Central bank foreign exchange purchases, in millions of US dollars.
XS	Central bank foreign exchange sales, in millions of US dollars.

Source: Authors.
Note: MONEX (Mercado de Monedas Extranjeras) is an organized electronic foreign exchange market provided by the Central Bank of Costa Rica.
[1] Annualization takes into account the several changes in MONEX's opening times during the sample period.
[2] In the sample period, there are only four 15-minute intervals during which the central bank both sold and purchased dollars. In these cases, the indicator takes the value of zero.

approach. This subsection discusses the two approaches in turn; the next one presents the key results.

Event Analysis

The event analysis compares the average variation rate (or volatility) of the exchange rate before and after a central bank foreign exchange intervention event, to see whether intervention affected the exchange rate in the expected (desired) direction. The approach in this chapter follows broadly the methodology laid out in the seminal study by Fatum and Hutchison (2003).[18] The advantage of this approach is that it does not rely on a theoretical model of exchange rate determination.

There are three critical steps in an event analysis:

1. Identification of the event: To identify intervention events, this chapter considers only interventions that are isolated; that is, where no other interventions take place in the reference windows before or after the intervention. This allows more precise assessment of the effects of the specific intervention event on the exchange rate path following the intervention, and it can treat the intervention as unanticipated. The intervention event itself is a 1-minute window.

[18] Other studies that have used event analysis for the assessment of intervention effectiveness are Fratzscher (2005) for advanced economies; Contreras, Pistelli, and Sáez (2013) for emerging markets; and Echavarría, Melo, and Villamizar (2014) for Colombia.

2. Definition of the length of the pre- and post-intervention windows: These windows should be long enough to identify relatively persistent, more sustained effects, but also short enough to isolate the analysis from the influence of third factors on the exchange rate. For robustness, we use, alternatively, 60-, 120-, and 180-minute windows.
3. Classification of events as effective (or not): To gauge the success of an intervention, we use different criteria depending on whether the impact variable is the rate of variation or the volatility of the exchange rate.

For the variation rate, an intervention at time t (for 1-minute intervals) is considered effective when at least one of the following three conditions is met:

- Moderation: The rate of appreciation (depreciation) is slower after an official foreign exchange purchase (sale). Thus, for example, if the exchange rate is appreciating (note that an appreciation is a negative rate of change, and therefore a moderation implies that the rate of change increases):

$$r_{t,t-n} < 0, r_{t,t+n} < 0, \text{ and } r_{t,t+n} > r_{t,t-n} < 0$$

- Reversal (change of trend): intervention reverses the direction of exchange rate variation. Thus, if the exchange rate was appreciating (depreciating), it depreciates (appreciates) after a purchase (sale). For example, in the case of an appreciation before a purchase intervention:

$$r_{t,t-n} < 0, \text{ and } r_{t,t+n} > 0$$

- Intensification: Depreciation (appreciation) increases after an official foreign exchange purchase (sale). For example, if the exchange rate is depreciating, and there is a foreign exchange purchase:

$$r_{t,t-n} > 0, \text{ and } r_{t,t+n} > r_{t,t-n}$$

If none of these three conditions is met (for example, the exchange rate is appreciating and a purchase intervention leads to a faster appreciation, or it is depreciating and a sale intervention leads to a faster depreciation), then the intervention is deemed to be ineffective.

For the analysis of volatility, there is one single criterion: whether it declines or increases after the intervention, regardless of whether it is a sale or a purchase. An intervention is deemed effective if the volatility in the period after the intervention is lower than in the period before. Two measures of volatility are used: the standard deviation of a 15-minute rolling window of the level of the exchange rate (by minute), which gives a sense of the volatility in colones; and the squared returns of 15-minute time frames, estimated as (ln(R_15^2 + 1))^1/2.[19]

[19] Between these measures, there is a correlation of 0.86.

Regression Analysis

To complement the event analysis, a regression approach is also undertaken. As discussed earlier, econometric assessments of the effectiveness of the exchange rate are plagued by endogeneity issues, which bias standard ordinary least squares (OLS) coefficients. This chapter uses a high-frequency dataset to help address this problem.

Following Payne and Vitale (2003), the effectiveness of interventions is studied through a linear regression of the 15-minute percentage variation of the C/US$ rate (r_t), or its volatility (r-dev$_t$) on leads and lags of alternative intervention indicators (as well as lags for the dependent variable):

- Intervention dummy indicators, whether aggregate (I_t) or broken down into sales (S_t) and purchases (P_t): For example, the specification for r_t and I_t is as follows:

$$r_t = \alpha + \sum_{j=8}^{-8} \beta_j I_{t+j} + \gamma_1 r_{t-i} + \varepsilon_t \tag{10.1}$$

- Intervention amounts: The size of intervention may convey a clearer signal about the authorities' intention (although it is likely also endogenously associated with the strength of the exchange rate trend it attempts to counter, which may bias the results). As for the intervention dummies, the amount indicators are used first in aggregate (X_t), where purchases take a positive sign and sales a negative one, or separating between these two (XP_t and XS_t, respectively). The specification takes the following form:

$$r_t = \alpha + \sum_{j=8}^{-8} \delta_j X_{t+j} + \gamma_1 r_{t-\mathrm{i}} + \varepsilon_t \tag{10.2}$$

Eight leads and lags of the intervention variable are considered to capture the effects of intervention in the 2-hour period before and after any intervention event. The idea of introducing leads is to test whether interventions are anticipated by the market. Different lead and lag lengths were used alternatively, but this did not affect the results. The number of lags of the dependent variable was chosen using partial autocorrelation tests and Akaike and Schwartz information criteria. The regression coefficients are estimated using OLS, with Newey-West standard errors.

Results

This section summarizes the main results for the two methods: event analysis and regressions. As will be shown, the event analysis suggests that foreign exchange interventions tend to be effective. The results for regression analysis are consistent with this, if somewhat less conclusive.

TABLE 10.5.

Effects of Intervention on the Rate of Variation of the Exchange Rate, 2013–18

	Time Frame								
	60 minutes			120 minutes			180 minutes		
	Total	Successful	%	Total	Successful	%	Total	Successful	%
Purchases	57	46	81	25	22	88	16	9	56
Moderation of appreciation		10	18		1	4		0	0
Reversion of appreciation		26	46		12	48		7	44
Intensification of depreciation		10	18		9	36		2	13
Sales	43	31	72	24	20	83	18	13	72
Moderation of depreciation		10	23		4	17		3	17
Reversion of appreciation		19	44		12	50		8	44
Intensification of depreciation		2	5		4	17		2	11

Source: Authors' calculations.

Results: Event Analysis

The event analysis suggests that central bank interventions have been effective in moving the rate of variation of the exchange rate in the desired direction. As Table 10.5 shows, interventions are highly successful, with the success rate increasing at 120-minute windows and then decreasing. Purchases are more effective than sales at shorter intervals, but sales show a more lasting effect, with a success rate of 72 percent at 180-minute time frames.

Table 10.6 shows the results for the success rate of intervention in reducing volatility. It indicates that central bank interventions reduce the volatility of the exchange rate in less than half of the cases (except in purchases in longer time frames).

However, a different conclusion is reached if the effect on the average volatility of the exchange rate is assessed. Figure 10.15 shows that mean volatility falls after an intervention, for both purchases and sales and regardless of the time frame considered. This implies that, although only a moderate proportion of interventions reduce the volatility of the exchange rate, they reduce it by a large margin.[20]

[20] The figure is based on squared returns, but the same result obtains if the standard deviation of the exchange rate is used.

TABLE 10.6.

Success Rate of Intervention in Moderating Exchange Rate Volatility, 2013–18

	Time Frame								
	60 minutes			120 minutes			180 minutes		
	Total	Successful	%	Total	Successful	%	Total	Successful	%
Total	100			49			34		
Purchases	57			25			16		
Sales	43			24			18		
Standard deviation									
Purchases		22	39		10	40		8	50
Sales		17	40		9	38		6	33
Returns									
Purchases		25	44		11	44		9	56
Sales		18	42		10	42		7	39

Source: Authors' calculations.

Overall, event analysis suggests that central bank foreign exchange interventions are fairly effective in moving the variation of the exchange rate in the desired direction and in reducing its volatility.

Results: Regression Analysis

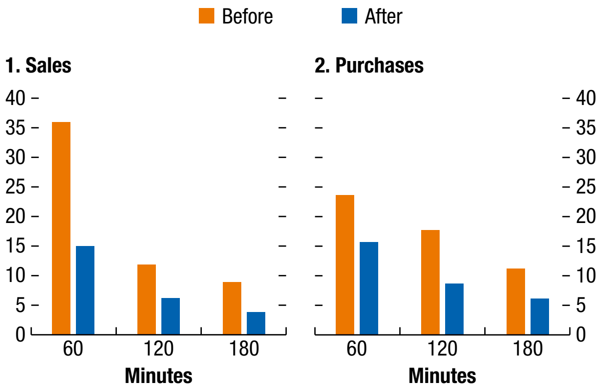
This section provides the results for the empirical estimation of equations (10.1) and (10.2), identified in the next six tables as model I and model II, respectively. Results are shown in aggregate (panel A) and breaking down interventions into sales and purchases (panel B). Only the coefficients for the relevant variables that turned out statistically significant are reported.[21]

The results for the rate of variation of the exchange rate (r_t) as dependent variable are shown in Tables 10.7 and 10.8. Table 10.7 presents the results for the intervention indicator (model I). It suggests that interventions generally have the desired (positive) effect on the variation rate, with a cumulative effect of 12.7 basis points for the aggregate intervention dummy (panel A). However, while purchases do have the expected positive sign, sales also have a positive sign (panel B). This suggests that sales tend to exacerbate, rather than mitigate, depreciation pressures on the exchange rate (although it may also be that the econometric methodology is unable to fully control for strong depreciation trends). It is also interesting to note that, in this and other specifications shown later, some leads tend to have statistically significant coefficients, which indicate that the effects of intervention are anticipated by the market.

Table 10.8 presents the results of the intervention amounts (model II). The coefficients show the effect of a \$1 million intervention over the 15-minute

[21] The following notation is used: *$p < .1$, **$p < .05$, and ***$p < .01$. Lagged dependent variables and the constant are omitted.

Figure 10.15. The Effect of Intervention on Mean Volatility of the Exchange Rate
(Percent)



Source: Authors' calculations.
Note: Volatility is measured by squared returns.

TABLE 10.7.

Effects on the Rate of Variation of the Exchange Rate: Model I

Panel A		Panel B	
Variable	**Coefficient**	**Variable**	**Coefficient**
I (+3)	16.98**	*P* (+1)	27.70***
I (0)	24.82***	*P* (0)	38.33***
I (−7)	−14.26**	*P* (−7)	−18.59***
I (−8)	−14.69**	*P* (−8)	−14.70**
		S (+2)	54.58**
		S (+1)	47.59**
Adjusted R^2	0.015	Adjusted R^2	0.018
Akaike information criterion	14.606	Akaike information criterion	14.603
Cumulative effect	12.67	Cumulative effect (*P*)	30.79
		Cumulative effect (*S*)	96.05

Source: Authors' estimation.
Note: The dependent variable is the rate of variation of the exchange rate (r_t). The total number of observations after adjustment is 25,646.
$^{**}p < .05$; $^{***}p < .01$.

variation rate of the exchange rate, annualized and measured in basis points.[22] For the aggregate intervention amount, the effects are negative but barely statistically significant at the 10 percent confidence level. For the disaggregated intervention

[22] This measure is based on the yearly schedule of MONEX and the number of negotiation days throughout the year.

TABLE 10.8.

Effects on Rate of Variation of the Exchange Rate: Model II

Panel A		Panel B	
Variable	**Coefficient**	**Variable**	**Coefficient**
X (+8)	−4.82*	*XP* (+3)	12.53***
X (+2)	−5.6*	*XP* (+2)	9.23**
		XP (0)	26.48***
		XP (−2	−14.98**
		XP (−3)	−19.89***
		XS (+7)	9.09**
		XS (0)	12.39***
		XS (−3)	−10.35**
		XS (−7)	−13.47***
Adjusted R^2	0.012	Adjusted R^2	0.015
Akaike information criterion	14.61	Akaike information criterion	14.61
		Cumulative effect (*P*)	12.56
		Cumulative effect (*S*)	−2.2

Source: Authors' estimation.
Note: The dependent variable is the rate of variation of the exchange rate (r_t). The total number of observations after adjustment is 25,646.
*$p < .1$; **$p < .05$; ***$p < .01$.

TABLE 10.9

Effects on Exchange Rate Volatility: Model I

Panel A		Panel B	
Variable	**Coefficient**	**Variable**	**Coefficient**
I (+7)	0.008**	*P* (+6)	0.010**
I (+6)	0.009**	*P* (+4)	−0.010**
I (+4)	−0.010**	*P* (+3)	−0.012***
I (+3)	−0.010***	*P* (+2)	−0.006**
I (+2)	−0.006**	*P* (+1)	−0.009***
I (0)	−0.012***	*P* (0)	−0.012***
I (−1)	−0.023***	*P* (−1)	−0.036***
I (−3)	0.010***	*P* (−3)	0.015***
I (−4)	0.012**	*P* (−4)	0.013***
I (−5)	0.006**	*P* (−5)	0.007**
I (−8)	0.006**	*P* (−7)	0.006**
		P (−8)	0.009***
		S (+8)	0.043**
		S (+1)	−0.023***
		S (−1)	−0.042***
		S (−7)	0.014**
Adjusted R^2	0.275	Adjusted R^2	0.281
Akaike information criterion	−0.45	Akaike information criterion	−0.45
Cumulative effect	−0.025	Cumulative effect (*P*)	−0.0822
		Cumulative effect (*S*)	−0.0255

Source: Authors' estimation.
Note: The dependent variable is the standard deviation of the exchange rate (*r–std*). The total number of observations after adjustment is 28,937.
**$p < .05$; ***$p < .01$.

TABLE 10.10.

Effects on Exchange Rate Volatility: Model II

Panel A		Panel B	
Variable	**Coefficient**	**Variable**	**Coefficient**
X (+7)	0.004**	*XP* (+7)	0.005**
		XP (+4)	−0.005**
		XP (0)	−0.010***
		XP (−1)	−0.014***
		XP (−2)	0.006**
		XP (−3)	0.008***
		XP (−4)	0.007***
Adjusted R^2	0.270	Adjusted R^2	0.272
Akaike information criterion	−0.438	Akaike information criterion	−0.441
Cumulative effect	0.011	Cumulative effect (*P*)	−0.0062

Source: Authors' estimation.
Note: The dependent variable is the standard deviation of the exchange rate (*r–std*). The total number of observations after adjustment is 28,937.
**$p < .05$; ***$p < .01$.

amounts, on the other hand, the effects are statistically significant and in the expected direction in cumulative terms, though the magnitude is asymmetric for purchases and sales. Thus, a $1 million purchase by the central bank leads to a depreciation of about 13 basis points, while a sale of an equivalent amount leads to an appreciation of about 2 basis points.

The analysis now reviews the effect of intervention on exchange rate volatility, using the standard deviation (Tables 10.9 and 10.10) and then the squared returns (Tables 10.11 and 10.12) as alternative measures of volatility.

We first review the results of the standard deviation; Table 10.9 presents the results for the intervention indicator. The results are clear: Intervention reduces the volatility of the exchange rate, and both purchases and sales contribute in this direction, but purchases have a much stronger effect.

If intervention amounts are used, however, the evidence is less conclusive (Table 10.10). The standard deviation of the exchange rate seems to increase with the amount of intervention, although the effect seems small (about 1 céntimo per $1.0 million intervention). The amount of sales does not have a statistically significant effect on volatility, but amounts purchased do have a small negative effect.[23]

The results are somewhat different if the squared returns of the exchange rate are used as a measure of volatility (Tables 10.11 and 10.12). In this case, interventions and intervention amounts do have a negative and statistically significant effect on the measured volatility, but sales and purchases only seem to reduce volatility when amounts are considered.

[23] If the standard deviation of the exchange rate over a 60-minute rolling window is used (instead of over a 15-minute window), the results are qualitatively similar, with interventions and intervention amounts contributing to a decline in volatility, and the effect of purchases being negative and statistically significant (while sales seem to have a small positive effect on the standard deviation).

TABLE 10.11.

Effects on Exchange Rate Volatility: Model I

Panel A		Panel B	
Variable	**Coefficient**	**Variable**	**Coefficient**
I (+2)	−13.54*	*P* (+2)	−13.97 ***
I (+5)	12.03**	*P* (−5)	12.45**
		P (−6)	−10.35**
		P (−7)	12.12**
		P (−8)	14.93***
Adjusted R^2	0.333	Adjusted R^2	0.335
Akaike information criterion	13.962	Akaike information criterion	13.962
Cumulative effect	−5.43	Cumulative effect (*P*)	55.45

Source: Authors' estimation.
Note: The dependent variable is the standard deviation of the exchange rate (*r–sq*). The total number of observations after adjustment is 20,160.
**$p < .05$; ***$p < .01$.

TABLE 10.12.

Effects on Exchange Rate Volatility: Model II

Panel A		Panel B	
Variable	**Coefficient**	**Variable**	**Coefficient**
X (+8)	−7.18**	*XP* (+8)	−9.01**
X (+3)	−9.28**	*XP* (+2)	−10.36**
X (0)	−13.17**	*XP* (0)	−10.23**
		XS (−7)	−10.43**
		XS (0)	−18.64**
Adjusted R^2	0.330	Adjusted R^2	0.330
Akaike information criterion	13.969	Akaike information criterion	13.970
Cumulative effect	−13.68	Cumulative effect (*P*)	−37.85
		Cumulative effect (*S*)	−120.38

Source: Authors' estimation.
Note: The dependent variable is the squared returns of the exchange rate (*r–sq*). The total number of observations after adjustment is 16,886.
**$p < .05$.

Overall, the evidence from regression analysis suggests that central bank foreign exchange intervention is effective in both pushing the exchange rate in the desired direction and reducing its volatility. This is particularly true of US dollar purchase interventions. The evidence on the effectiveness of sales, on the other hand, is more mixed, with some specifications suggesting that selling does not help appreciate the exchange rate nor mitigate its volatility.

CONCLUSIONS

Data from Costa Rica clearly illustrates that learning to float is not easy, particularly amid significant structural constraints. Although it transitioned to a managed floating regime (effectively since late 2013, and de jure since early 2015), the central bank has continued to engage in active sterilized exchange rate interventions—so actively that the de facto exchange rate regime has been classified by the IMF as "crawl-like" or "stabilized" over the past few years.

This chapter has argued that two factors contribute to such fear of floating by the central bank:

- The likelihood of sharp fluctuations, in the context of a thin and relatively concentrated spot market (MONEX), where a few powerful participants can wield a disproportionately high influence on price formation, and therefore have an incentive to engage in self-fulfilling speculation. With still very underdeveloped derivatives markets, MONEX is the market where all official foreign exchange intervention takes place.
- The likelihood of potentially deleterious effects of such fluctuations on price expectations and financial stability, against the background of a (still) considerable pass-through coefficient and a high degree of currency risk in household and corporate balance sheets, with limited availability of hedging instruments.

It is therefore understandable that the main rationale for official intervention in Costa Rica be to contain "violent" fluctuations in the exchange rate. As this chapter has shown, even interventions in MONEX, which are ostensibly intended for reserve accumulation or to meet the needs of the nonfinancial public sector, are, in practice, conducted in such a way as to help mitigate excessive volatility or at least to avoid exacerbating it. Moreover, while all intervention information is published ex post, interventions are not announced ex ante, and central bank rules for stabilization interventions are kept confidential. Official communications, particularly through press releases, are used to support actual interventions in MONEX, and effectively represent another channel of intervention. The central bank's justification of this mixed approach to transparency is that advance information to markets may be used by large players for speculative gain, with potentially destabilizing effects.

Has the Costa Rican central bank been successful in its stabilization attempts? The answer is not straightforward, given that the formal empirical analyses are fraught with endogeneity and identification problems. This chapter has sought to overcome the standard endogeneity and identification problems in empirical analyses by deploying two different approaches on a high-frequency dataset. It finds that official foreign exchange intervention has been broadly effective in containing exchange rate fluctuations, whether measured by the rate of variation of the exchange rate, or its volatility. The ultimate evidence in favor of the effectiveness of intervention is in the observed path of the exchange rate itself: a simple chart shows that it has been relatively stable in the floating period—hence the soft peg classification by the IMF.

Going forward, the central bank could consider preannouncing interventions to meet the needs of the nonfinancial public sector. This may help to increase the potency and signaling effects of foreign exchange interventions for stabilization purposes. The central bank could also consider allowing greater exchange rate flexibility. As extensively pointed out (IMF 2017; Lizano 2018), high financial dollarization is endogenous to the exchange rate regime, and greater de facto flexibility would stimulate agents to internalize exchange rate risks more fully, thereby reducing financial vulnerabilities. In addition, greater exchange rate flexibility would help buttress the credibility of the monetary policy framework, as confidence would be strengthened in the primacy of the price stability objective over exchange rate stability. This, in turn, would contribute to a continued decline in the pass-through coefficient from exchange rate shocks to inflation.

As in swimming, the best way to learn to float may be to let go gradually.

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Mexico: Free-Floating Exchange Regime

Rodrigo Cano, Daniela Gallardo, and Jaime Acosta

This chapter describes Mexico's experience with foreign exchange intervention since the free-floating exchange rate regime was adopted in December 1994. The first two sections describe the background of the different intervention mechanisms that have been used over time, along with the stated objectives of those interventions. The third section presents a set of analyses of the interventions' effectiveness. The main takeaways from that section are that interventions with the objective to achieve a specific stock of international reserves have been very effective. However, it is difficult to assess the effectiveness of interventions if the objective is to temper foreign exchange volatility, because the central bank does not have the counterfactual case to compare what would have been the outcome without the intervention. Despite those difficulties, there is some statistical evidence to infer that the Bank of Mexico's interventions in the foreign exchange market to temper volatility have been effective. The next sections describe how the size and timing of interventions were decided, as well as the communication policies that were followed. The last section provides final remarks on what has been learned in Mexico about foreign exchange interventions.

INTRODUCTION

For more than 20 years, the Mexican peso has been floating freely, based on market forces. For this reason, since 1995, foreign exchange interventions have not been used to set the exchange rate. Instead, interventions have aimed at other objectives, such as managing the stock of international reserves or reducing exchange rate volatility during unusual financial market situations. Over time, different mechanisms have been used, depending on these objectives and on market conditions. Before every intervention, authorities perform a rigorous analysis to decide how to intervene and how to communicate this decision to the market.

This chapter details this experience in Mexico. It describes the background and intervention mechanisms used and the stated objectives of those interventions. Also, the chapter reviews the interventions' effectiveness and describes how the size and timing of interventions were decided, along with the communication policy. The final remarks of this chapter summarize the lessons learned.

The opinions expressed in this chapter are the sole responsibility of the authors and are not necessarily those of the Bank of Mexico.

FROM CRAWLING PEG TO FREE FLOATING

In December 1994, after the depletion of international reserves, the Foreign Exchange Commission (FX Commission)[1]—integrated by officials of both the Bank of Mexico and the Ministry of Finance—decided to move from a crawling peg regime to a free-floating regime. Since then, interventions in the foreign exchange market have responded to various scenarios by selling and buying international reserves. Most of these interventions were implemented through pre-announced auction-based mechanisms. The use of extraordinary auctions and discretionary interventions was restricted to extreme circumstances. Interventions have been designed to manage the stock of international reserves or to temper extreme exchange rate volatility, but not to set a level for the exchange rate. In this regard, foreign exchange interventions have been executed to be compatible with the free-floating exchange rate regime. (Figure 11.1 shows the trend of international reserves since 1994 and indicates some of the main foreign exchange intervention periods.)

After the liberalization of the exchange rate in 1994, the only local institution that was subject to restrictions on operating in the foreign exchange market was Pemex, the state-owned oil company. As mandated by the Bank of Mexico's law, all nonfinancial entities in the Federal Public Administration must operate in the foreign exchange market according to the rules and policies set by the central bank, so that large trade surpluses or deficits do not distort the exchange rate through market dominance. Letting Pemex freely operate in the foreign exchange market was not viable in 1994, because it had a large trade surplus, which could distort the exchange rate and give Pemex a dominant position over foreign exchange policy. Because of the regulatory framework, Pemex was, for many years, the main source of international reserves accumulation that are administered by the central bank (Figure 11.2).

The Federal Government is the other institution that has executed foreign exchange operations—almost exclusively with the central bank. It buys US dollars from the central bank to service foreign debt. When the Federal Government issues debt denominated in foreign currency, depending on its currency needs, it can sell part or all of those resources to the central bank. Figure 11.2 presents the main sources of accumulation that explain the movements in international reserves.

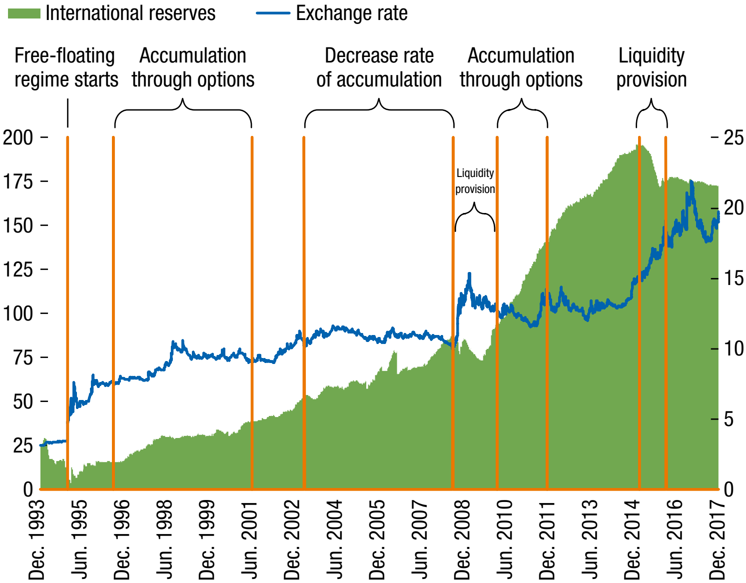
MECHANISMS AND OBJECTIVES

Since 1996, all the mechanisms to intervene in the foreign exchange market were determined by the FX Commission and executed by the Bank of Mexico. In

[1] The FX Commission, which oversees Mexican foreign exchange policy, comprises three members of the Ministry of Finance (the minister and two deputy ministers) and three members from the Bank of Mexico's board (including the governor). The minister of finance chairs the Commission and has the casting vote. In the absence of the minister of finance, the central bank's governor presides over the session.

Figure 11.1. Bank of Mexico's International Reserves and the Mexican Peso Exchange Rate, 1993–2017

(Billions of US dollars, left scale; Mexican peso per US dollar, right scale)



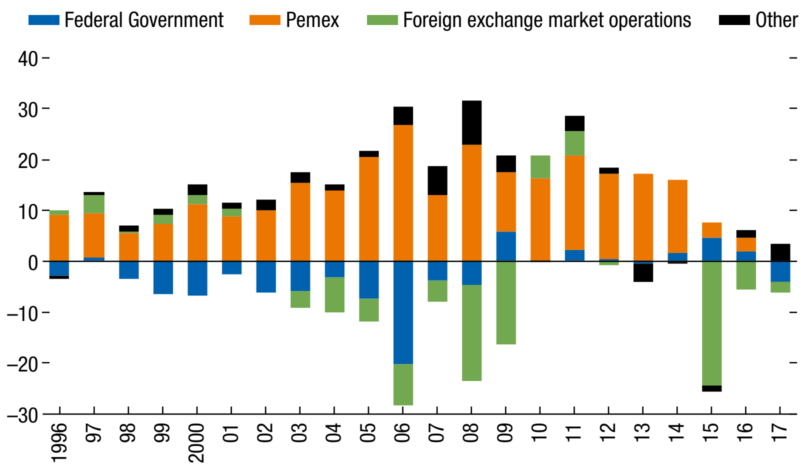
Source: Bank of Mexico.
Note: The Bank of Mexico's law defines international reserves as foreign assets owned by the Bank of Mexico, excluding the government's and other's short-term deposits.

general terms, some mechanisms were used to aim for a certain level of international reserves—either to accumulate reserves or to reduce the pace of accumulation. In other cases, intervention mechanisms aimed to provide liquidity to the market, given that its main goal is to ensure proper operating conditions and to reduce volatility. In all cases, the level of the exchange rate has not been targeted.

The mechanisms used to accumulate or reduce the pace of accumulation of international reserves considered the level of reserves at the time of implementation as well as other criteria. There is no single uniquely accepted metric to assess the sufficiency of international reserves. The central bank uses several metrics to assess reserve adequacy, but because results can vary, it relies on the FX Commission's judgment. The metrics used to assess sufficiency include (1) the ratio of reserves to GDP, compared with the ratio in other emerging markets; (2) the reserve adequacy metric proposed by Moghadam, Ostry, and Sheehy (2011) from the IMF; (3) cost-benefit approaches, such as the one proposed by Calvo, Izquierdo, and Loo-Kung (2012); and (4) utility-maximizing approaches, such as the one that Rancière and Jeanne (2006) developed.[2] The following sections outline the foreign exchange intervention mechanisms used.

[2] These metrics are described later in this chapter.

Figure 11.2. Bank of Mexico's International Reserves: Sources of Accumulation, 1996–2017
(Billions of US dollars)



Source: Bank of Mexico.
Note: The sixth edition of the Balance of Payments Manual defines official reserve assets as those external assets that are readily available to and controlled by monetary authorities for meeting balance of payments financing needs, for intervention in exchange markets to affect the currency exchange rate, and for other related purposes (such as maintaining confidence in the currency and in the economy, and serving as a basis for foreign borrowing).

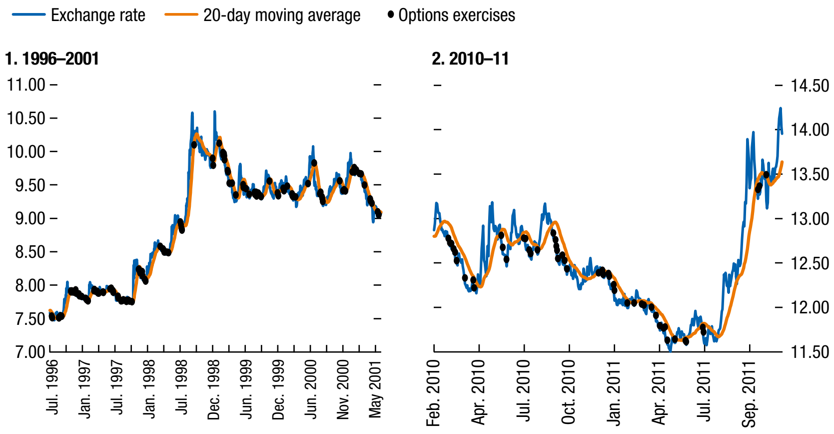
Accumulation of International Reserves through Put Options

The accumulation of international reserves through a put options mechanism was first used from August 1996 through June 2001. By 1996, the natural pace of reserve accumulation through Pemex's sales of US dollars to the central bank was not enough to bring international reserves to what was deemed a sufficient level. If intervention was needed to contain extreme volatility, reserves would not suffice. In addition, after the 1994 financial crisis, international investor and credit rating agency confidence needed to be restored.

The FX Commission therefore decided to implement a reserve accumulation mechanism, under which the central bank sold US dollar put options to the market through monthly auctions. These options gave financial institutions the right to sell US dollars to the central bank during the following month, subject to certain conditions. The first condition was that the exchange rate of exercise (strike price) was the FIX exchange rate determined by the central bank the business day before the exercise[3]. As a second condition, the option could be executed

[3] The FIX exchange rate is determined by the Bank of Mexico as an average of quotes in the wholesale foreign exchange market for operations payable in 48 hours. The central bank informs the FIX from 12 o'clock onward each banking day. It is published in the Official Gazette (*Diario Oficial de*

Figure 11.3. Mexican Peso to US Dollar Exchange Rate: Options Exercises, 1996–2001 and 2010–11
(Mexican peso per US dollar)



Source: Bank of Mexico.

only when the exercise exchange rate was below its 20-day moving average (Figure 11.3). This way, international reserve accumulation would occur during Mexican peso appreciation periods; that way, the mechanism did not put pressure on the exchange rate in a depreciation trend. The mechanism allowed the central bank to purchase US dollars with the least possible interference with the free-floating exchange rate regime. Total US dollars bought by the central bank during that period was $12.2 billion (Table 11.1, panel 1).

This mechanism was used again, with the same conditions, from February 2010 through November 2011, to restore international reserves after the central bank sold more than $30 billion during the 2008–09 global financial crisis. During that period, the central bank accumulated $9.1 billion through the mechanism. Table 11.1 (panel 2) shows the results of these auctions during 2010 and 2011.

Foreign Exchange Sales to Slow the Accumulation of International Reserves

The foreign exchange sales to slow the accumulation of international reserves mechanism was in place from May 2003 through July 2008. After the suspension of the reserve accumulation program through put options, with the sole accumulation derived from Pemex's US dollar sales, international reserves reached a level

la Federación) one banking business day after its determination date, and it is used to settle liabilities denominated in US dollars payable in Mexico on the day after its publication in the Official Gazette.

TABLE 11.1.

Options Auctions and Exercises, 1996–2001 and 2010–11
(Billions of US dollars)

1. 1996–2001

Year	Purchased	Exercises
1996	0.9	0.9
1997	5.2	4.5
1998	2.8	1.6
1999	3.0	2.0
2000	3.0	1.8
2001	1.5	1.4
Total	16.4	12.2

2. 2010–11

Year	Purchased	Exercises
2010	6.6	4.5
2011	6.0	4.6
Total	12.6	9.1

Source: Bank of Mexico.

where the benefits of future expected accumulation were beginning to be outnumbered by their financial costs (cost of carry). Thus, the FX Commission introduced this mechanism by selling, in a given quarter, half the amount accumulated during the previous quarter. At the beginning of each selling period, the central bank announced the daily amount to be auctioned. To smooth the amount sold each quarter, the previous quarter's accumulation reference was changed by a moving average of the previous four quarters' accumulation, avoiding the volatility inherent in the seasonality of reserve accumulation. Because the amount of central bank US dollar sales was predetermined, and resulted from previous accumulation, the interference with the free-floating regime was minimized. During the years in which this mechanism was implemented, $30.1 billion were sold through auctions (Table 11.2).

US Dollar Daily Auctions with Minimum Bid Price

The US dollar daily auctions with minimum bid price mechanism was used during several periods to limit extreme exchange rate volatility and provide liquidity to ensure proper operating conditions in the foreign exchange market, but never to fix a prespecified level for the exchange rate. Under this mechanism, the central bank auctions a prespecified amount of US dollars every day and sets a minimum accepted price. This way, the trigger to sell US dollars to the market is predetermined by market conditions without meddling with the free-floating exchange rate regime. This tool was first used from February 1997 through June 2001; during that time, the minimum price accepted was set equal to the FIX exchange rate, which was determined the previous day plus a 2 percent depreciation factor. Therefore, only when the exchange rate depreciated by 2 percent or more, would the auctions be allotted (Figure 11.4, panel 1). A total of $2 billion were sold with this mechanism during this period (Table 11.3).

The mechanism was used again, with the same characteristics, during the global financial crisis (from October 2008 through April 2010; see Figure 11.4,

TABLE 11.2.

International Reserves Sold, 2003–08
(Billions of US dollars)

Year	Amount
2003	3.2
2004	6.7
2005	4.4
2006	8.1
2007	4.2
2008	3.5
Total	30.1

Source: Bank of Mexico.

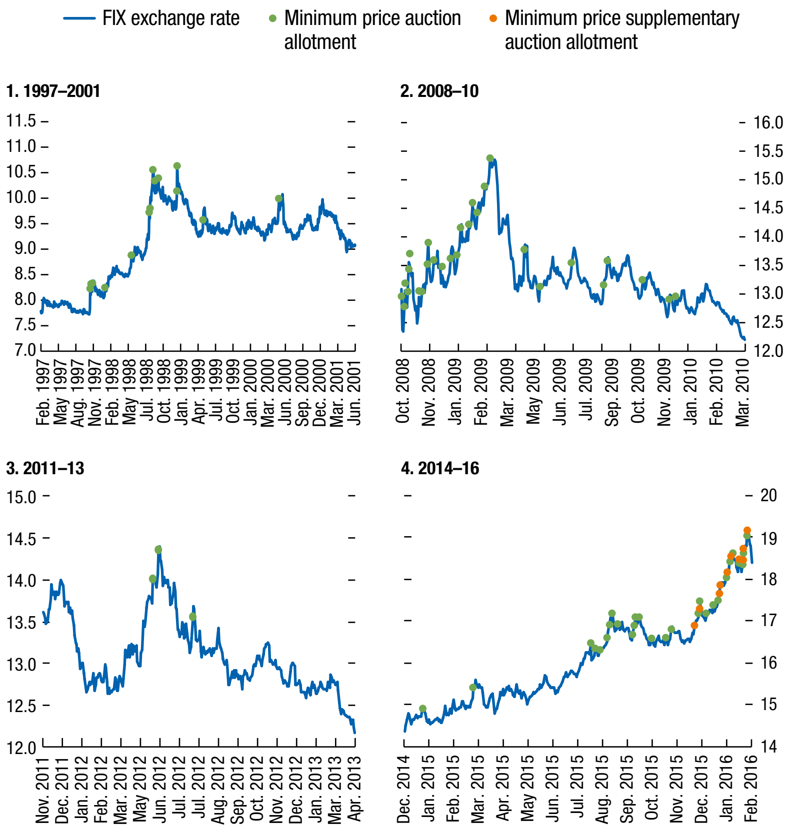
panel 2) and during the European financial crisis (from November 2011 through April 2013; see Figure 11.4, panel 3). It was used also from December 2014 through February 2016 to provide the liquidity to ensure the proper operating conditions in the foreign exchange market and to temper the volatility in the exchange rate generated by the drop in oil prices. During this last period, the mechanism was modified several times to increase the amount of US dollars to be offered. Initially, in December 2014, the minimum accepted price was set at the FIX exchange rate determined the previous day plus a 1.5 percent depreciation factor (instead of the previous 2.0 percent depreciation factor). Then, in July 2015, the minimum price threshold was adjusted by using a 1.0 percent depreciation factor. And in that same month, supplementary daily auctions with a minimum price equivalent to a 1.5 percent depreciation of the previous day's FIX were added to the toolkit (Figure 11.4, panel 4).

US Dollar Daily Auctions without a Minimum Bid Price

Sometimes, a constant demand for US dollars that could distort operating conditions and generate volatility is expected to persist. Under those scenarios, the FX Commission has used daily auctions of US dollars for determined amounts and periods, without a minimum price. In 2009, the FX Commission decided to provide additional liquidity to improve the operating conditions in the foreign exchange market; hence, it introduced daily auctions of US dollars without a minimum price. This mechanism was in operation from March through September 2009, and a total of $10.3 billion was sold, with initial daily auctions of $100 million that were later reduced to $50 million.

This mechanism was used again from March through November 2015, with the total amount offered corresponding to the expected accumulation of international reserves during the following quarter. For the first three-month period, the daily amount offered was set at $52 million, but it later increased to $200 million, as market conditions demanded (Figure 11.5, panel 2). A total of $20.7 billion was sold through this intervention tool.

Figure 11.4. Mexican Peso to US Dollar Exchange Rate: Minimum Price Auctions, 1997–2001 and 2008–16
(Mexican peso per US dollar)



Source: Bank of Mexico.

Extraordinary US Dollar Auctions

Even though the FX Commission has traditionally shown a preference to intervene in the market through rules-based and preannounced operations, it has also employed extraordinary auctions offering large amounts of US dollars. In October 2008, during the worst part of the global financial crisis, the Mexican peso depreciated more than 20 percent in one week alone, and the movement was not considered to be aligned with Mexico's macroeconomic fundamentals. Moreover, operating conditions were dramatically distorted. To provide liquidity and restore the well-functioning of the foreign exchange market, therefore, the FX Commission, in five extraordinary auctions, sold \$11 billion. One of those interventions amounted to more than \$6 billion.

TABLE 11.3.

International Reserves Sold with Minimum Price Auctions, 1997–2016

(Billions of US dollars)

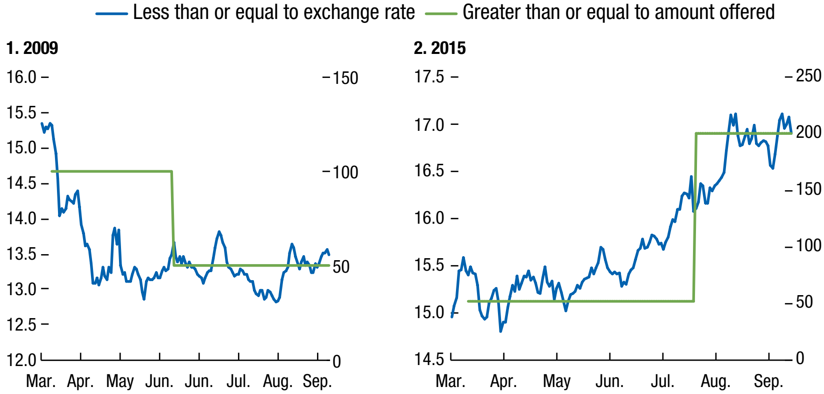
Year	Sold
1997	0.6
1998	0.9
1999	0.4
2000	0.1
2001	0
2008	4.2
2009	4.2
2011	0
2012	0.6
2013	0
2014	0.2
2015	3.8
2016	3.6
Total	18.6

Source: Bank of Mexico.

US Dollar Discretionary Outright Sales

Since the beginning of the free-floating exchange rate regime, the FX Commission has resorted to discretionary interventions, through outright sales of US dollars, only in four episodes of extreme volatility. As with the preannounced mechanisms, this type of intervention is meant to reestablish orderly market operating conditions and does not target a specific level for the exchange rate. When a discretionary intervention takes place, the FX Commission releases a press bulletin to inform the public immediately after the intervention. Even though the amount of the intervention is not usually disclosed in these press releases, the central bank publishes the stock and flows of the international reserves on a weekly basis, and the aggregated amount of intervention is disclosed. The first time that discretionary sales took place during the free-floating period was in September 1998, during the Russian and Brazilian crises. Almost a decade later, during February 2009, in the middle of the global financial crisis, conditions in the foreign exchange market justified direct intervention with local market participants. Then, in February 2016, when oil prices reached very low levels, worsening Mexico's fiscal position, all predetermined mechanisms previously in place were suspended, and a discretionary US dollar sale was conducted. In January 2017, as market conditions deteriorated as a result of the new US administration's inauguration, the FX Commission decided to intervene in a discretionary manner to restore operating conditions. This last intervention was the first time that the

Figure 11.5. Mexican Peso to US Dollar Exchange Rate and Nonminimum Price US Dollar Daily Auctions, 2009 and 2015
(Mexican peso per US dollar, left scale; millions of US dollars, right scale)



Source: Bank of Mexico.

Bank of Mexico operated in the Mexican peso exchange market with nonresident counterparts.[4]

US Dollar Credit Auctions

To provide additional sources of US dollars to the Mexican private sector during the global financial crisis, the Bank of Mexico auctioned credit in US dollars to banks, which they, in turn, could lend to firms. International reserves were not used, as the resources came from a swap line established with the Federal Reserve Bank of New York. This mechanism was used only once, in April 2009. The central bank auctioned $4 billion, from which $3.2 billion were allotted.

Foreign Exchange Hedge Auction Program (Nondeliverable Forward Auctions)

Given the fall in oil production and prices of the past three years, Pemex has, since 2016, registered a negative trade balance. Also, since 2016, Pemex has not been selling US dollars to the Bank of Mexico, so the traditional main source to accumulate international reserves has disappeared, at least in the short and medium terms.

[4] Previous interventions had been conducted exclusively with banks licensed and domiciled in Mexico. In this last intervention, for the first time, the Bank of Mexico operated in the Mexican peso exchange market with institutions located outside Mexico. The objective was to show the market that the central bank was capable of intervening at any time, even during hours of poor liquidity.

In this environment, the FX Commission needed an intervention mechanism that prevented the stock of international reserves from falling. At the same time, the FX Commission wanted a mechanism to provide a foreign exchange hedge to market participants; so it introduced the auctions of nondeliverable forwards settled in Mexican pesos in February 2017. Through this instrument, market participants bid for the forward exchange rate they need at the maturity of the contract. If the exchange rate at the time of maturity is higher than the forward exchange rate assigned in the auction (a depreciation takes place), the commercial bank that owns the contract makes a profit that is settled in pesos. In this way, the commercial bank ensures that it has the exact number of pesos it needs to buy the notional amount of US dollars embedded in the foreign exchange hedge contract. In contrast, if the exchange rate at the time of maturity is lower than the forward exchange rate assigned in the auction (an appreciation takes place), the commercial bank that owns the contract ends up with a loss that is settled in pesos. Even with this loss, the commercial bank ensures that it has the exact number of pesos it needs to buy the notional amount of US dollars embedded in the foreign exchange hedge contract.

The program was announced for a notional amount of up to $20 billion. An initial auction for $1 billion was allotted in March 2017. Afterward, during the fourth quarter of 2017, additional auctions of $4.5 billion took place. One important characteristic of this mechanism is that, at each expiration, all nondeliverable forward positions are rolled over until the FX Commission deems it necessary to continue.

It is important to mention that, even though this mechanism does not undermine the amount of US dollars available to intervene in the spot market, it represents a short position of US dollars for the central bank. As a result, if the use of this mechanism begins to represent an important share of the stock of international reserves, even though their availability is not changed, there would be a signaling effect that many market analysts and rating agencies could begin to highlight in their credit assessments.

Flexible Credit Line with the IMF to Supplement Current International Reserves

In 2009, Mexico was one of three countries able to access the IMF Flexible Credit Line facility. The facility is only available for economies with sound economic fundamentals and policies, and its objective is to enhance their economic position in the event of external shocks. The credit line represents potential additional reserves for intervening in the foreign exchange market. Even though the credit line has not been used, it has been renewed several times. In the first installment (2009), the credit line was for special drawing rights (SDRs) 31.5 billion (about $47 billion), and it increased 50 percent in 2011. In 2016, the amount available in SDRs increased again, by more than 30 percent, reaching SDR 62.4 billion (close to $90 billion).

Intervention Effectiveness

To determine the effectiveness of a foreign exchange intervention, its objective has to be very well defined. In this regard, when the Bank of Mexico bought or sold US dollars to accumulate international reserves or to reduce the pace of accumulation, respectively, the interventions were quite effective. Every time the auction of put options described above was in place, the central bank accumulated more reserves, and every time a mechanism to reduce the pace of accumulation was used, the central bank accumulated fewer reserves than it would have without the mechanism. Hence, the Bank of Mexico's foreign exchange interventions were quite effective.

When the aim of interventions is to provide liquidity to the market, to ensure operating conditions in the foreign exchange market, and to temper volatility, it is difficult to determine their effectiveness. For example, even if volatility does not go down after intervention, it is not necessarily true that the intervention was ineffective. In fact, central banks do not have the counterfactual case to compare what would have been the outcome without the intervention. Therefore, any result from an analysis of the efficiency of interventions should be taken with caution.

The theoretical literature on this topic proposes several channels through which sterilized central bank interventions could influence the economy. These channels are known as the "portfolio balance channel," the "signaling channel," and the "equilibrium selection channel." The idea behind a portfolio balance channel is that if different currencies are not perfect substitutes, for investors to absorb an increase in the supply of an asset denominated in a currency, they will demand higher returns on that asset. Therefore, a sterilized intervention (an increase in the supply of US dollars) will result in an increase in the price of the currency relative to the US dollar (for more information, see Canales-Kriljenko, Karacadag, and Guimaraes 2003).

The second channel proposed in the theoretical literature is the signaling or "expectations" channel. This channel suggests that exchange market interventions do not have an effect on their own, but they do contain information about future monetary policy.

The third channel revealed in the literature is the "equilibrium selection channel." This channel relies on the deviation of the exchange rate from the level that fundamental conditions warrant and can be underpinned (Shleifer and Vishny 1986). In that case, expected future actions of a large market participant can convince fundamentally driven investors to enter the market and bet on the right currency level (Shleifer and Vishny 1986).

The empirical literature has not arrived at a consensus about the effectiveness of currency market interventions. The literature that focused on developed economies has found mixed results (Neely 2005). While interventions have generally been found to have small effects, some interventions seem to have been effective, particularly those associated with large interventions coordinated among several central banks. The literature that focuses on developing economies has not reached a consensus either. Although evidence suggests that some interventions have been effective, no regular circumstances or intervention forms have been deemed more effective than others (Broto 2012).

García-Verdú and Ramos-Francia (2014) evaluate the intervention effects for Mexico on the expected exchange rate, using derivatives market data through a linear regression model. The authors find little evidence of an effect on the expected exchange rates' distribution. In some cases, they find statistical evidence of a certain effect. However, it tends to be short-lived or not economically significant.

To summarize, this section assesses the efffectiveness of foreign exchange interventions to provide liquidity to the foreign exchange market for ensuring adequate operating conditions and tempering foreign exchange volatility. To make an adequate assessment, the first step is to determine whether the foreign exchange interventions altered the behavior of the exchange rate following a principal component approach. The second step is to use traditional econometric methodologies to assess the effectiveness of those interventions. The section considers the effect of these interventions over the different moments of the volatility and bid-ask spread distributions.

MEASURING THE EFFECT OF FOREIGN EXCHANGE INTERVENTIONS OVER THE BEHAVIOR OF THE EXCHANGE RATE WITH A PRINCIPAL COMPONENT APPROACH

This section analyzes the effects on the exchange rate before and after specific interventions. The observed exchange rate is compared with a portfolio of twelve currencies that displayed a high correlation with the Mexican peso before each intervention.[5] The underlying assumption is that, in the absence of idiosyncratic shocks to the Mexican peso, it should follow the movements of this currency portfolio (referred to as synthetic MXN hereafter). The synthetic MXN is based on a principal component approach in which currency weights are determined by the linear combination of the three first principal components that explain 85 percent of the variance of these currencies against the US dollar.[6]

The methodology is applied to five different episodes in which the Bank of Mexico intervened in the foreign exchange market, using a time frame of 96

[5] The currencies included are the South African rand, Canadian dollar, Colombian peso, Turkish lira, Brazilian *real*, Chilean peso, Singapore dollar, Peruvian sol, Polish zloty, Australian dollar, New Zealand dollar, and the Czech koruna.

[6] With this approach, the main factors that explain the joint movement of all the currencies in the basket are captured in one single variable. This approach also rules out idiosyncratic effects of a particular currency included in the synthetic portfolio—for instance, the effect of any exchange rate intervention in any of the currencies included in the portfolio or any other relevant episode.

hours (4 days) before and after each of these foreign exchange policy actions.[7] The five episodes represent three different kinds of foreign exchange interventions:

1. The announcement of US dollar auctions in December 2014 and March 2015, with and without a minimum price, respectively;
2. The implementation of two direct interventions in the foreign exchange market, one in February 2016 and the other one in January 2017; and
3. The announcement of the foreign exchange hedge auctions program of February 2017.

The results of the analysis are in the following section.

Announcement of US Dollar Auctions

As noted, on December 8, 2014, the FX Commission began the "USD daily auctions with minimum bid price" mechanism. On March 11, 2015, the FX Commission announced the "USD daily auctions without a minimum bid price."

Under the methodology, a synthetic MXN was calculated for the four days after each of those two announcements of interventions. Figure 11.6 shows that before the intervention, in both cases, the observed Mexican peso was depreciated relative to the synthetic MXN; after the intervention, the observed Mexican peso turned out to have appreciated relative to the synthetic MXN—meaning that it is likely that those announcements affected the exchange rate. In both cases, in the four days after the announcement, the observed Mexican peso was approximately 1.5 percent more appreciated than the synthetic MXN. The outperformance of the Mexican peso relative to the synthetic MXN could be explained by US dollar liquidity injected by the central bank. However, it is not possible, with a high degree of confidence, to derive this conclusion from this analysis, because idiosyncratic factors of the Mexican economy may have affected the Mexican peso behavior.

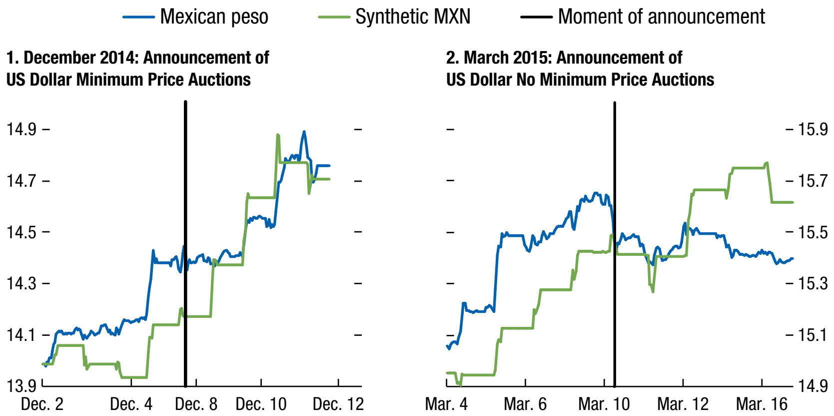
Direct Interventions in the Foreign Exchange Market

In February 2016 and January 2017, the FX Commission instructed the Bank of Mexico to sell US dollars outright in the market to supply liquidity and ameliorate observed volatility; it did so without targeting a determined level for the exchange rate. The outright intervention of February 2016 was followed by a very benign context in the global financial markets, driven by a recovery in oil prices after a sharp decline. Figure 11.7 shows that the Mexican peso outperformed the synthetic MXN in the four days after the intervention.

The outright intervention of January 2017 was followed by a negative environment in the global financial markets, ahead of the inauguration of a new US government. In this case, the Mexican peso underperformed the synthetic MXN

[7] The base time is the observation in the window period (the fifth day before the intervention). A longer window period was not considered, as it could cause issues by including other episodes that may have affected the exchange rate.

Figure 11.6. Mexican Peso and Synthetic MXN with Auction Announcements
(Mexican peso per US dollar)



Source: Bank of Mexico's estimates, using Bloomberg Finance L.P. data.

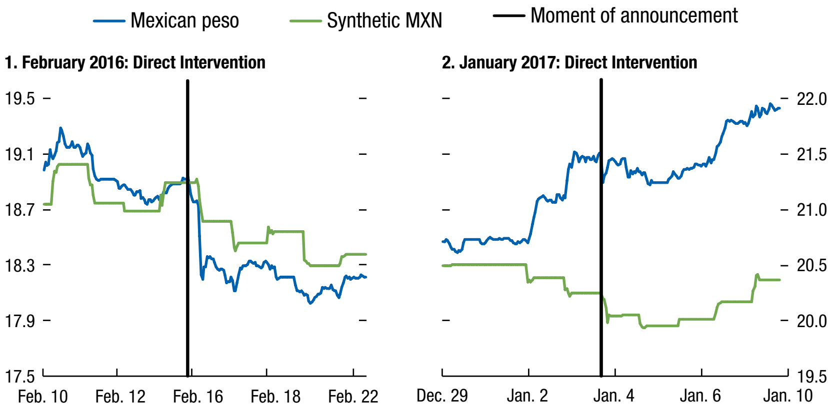
in the first days after the intervention. By no means can this behavior be interpreted as an ineffective intervention. As noted, it is not straightforward to measure what would have been the behavior of the Mexican peso without the US liquidity provided by the central bank.

On February 2017, the FX Commission announced the implementation of the foreign exchange hedge auctions program described earlier. In this case, the Mexican peso clearly outperformed the synthetic MXN (Figure 11.8). As in the previous cases, this behavior could be explained by the implementation of the foreign exchange mechanism. However, that cannot be strongly concluded, because of possible idiosyncratic factors in the Mexican economy during those days.

Plenty of evidence in the economic literature proves that the stock of international reserves enhances resilience to external shocks. In general, the economic literature related to adequate international reserves establishes that a larger amount of reserves diminishes the probability of a sudden stop; for example, cost-benefit approaches, such as the one proposed by Calvo, Izquierdo, and Loo-Kung (2012). Therefore, using a mechanism that does not reduce the amount of US dollars available to intervene in a shock to the balance of payments, may send a signal that the external accounts remain strong, and therefore, the impact of the intervention may be more effective.

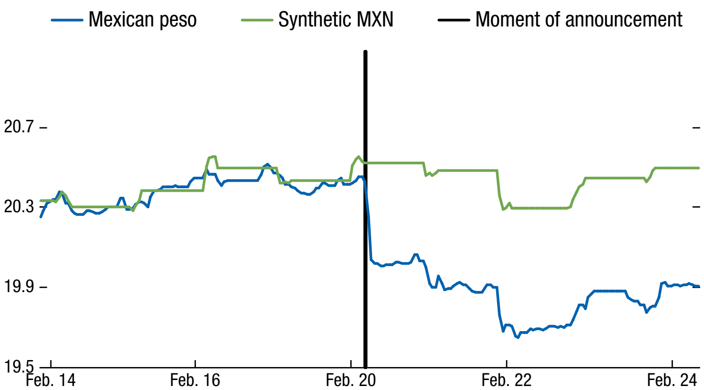
Even though other idiosyncratic factors could be affecting the behavior of the Mexican peso, it might also be suggested that foreign exchange interventions tend to temper strong depreciations of the currency.

Figure 11.7. Mexican Peso and Synthetic MXN with Direct Interventions
(Mexican peso per US dollar)



Source: Bank of Mexico's estimates, using Bloomberg Finance L.P. data.

Figure 11.8. Mexican Peso and Synthetic MXN with Hedge Auctions Announcement, February 2017
(Mexican peso per US dollar)



Source: Bank of Mexico's estimates, using Bloomberg Finance L.P. data.

REGRESSION ANALYSIS OF THE EFFECT OF INTERVENTIONS ON OPTION-IMPLIED VOLATILITY AND SKEWNESS

Another measure of the effectiveness of foreign exchange interventions is the analysis based on an exercise similar to García-Verdú and Ramos-Francia (2014), using regression analysis to evaluate intervention effects on different features of market expectations about the Mexican peso. Different models were estimated for the options-implied volatility and skewness of the currency (in levels and differences). The specification for each model is given by the following:

$$y_t^{MEX} = \beta_0 + \sum_{i=1}^{n} \beta_i y_{t-i}^{MEX} + \beta_{n+1} Int_t + \beta_{n+2} CF\_CAD_t + \beta_{n+3} CF\_LA_t + \varepsilon_t,$$

where Int_t represents the intervention dummy, y_t^{MEX} corresponds to the variable of interest for Mexico at time t (volatility or skewness), $CF\_CAD_t = y_t^{CAD}$ is the corresponding variable for Canada in the contemporaneous period, and $CF\_LA_t = \frac{1}{4}\sum_{j=1}^{4} y_t^{j}$ with $j \in \{Brazil, Chile, Colombia, Peru\}$ is the average of the corresponding variable for Latin American economies in the contemporaneous period.

The main result of the estimation using this approach (Table 11.4) is that, controlling for the behavior of the currencies of similar countries (Brazil, Chile, Colombia, and Peru) as well as Canada, the average effect of interventions during 2010–17 has been a significant decrease in the options-implied, short-run volatility of the exchange rate. Quantitatively, the estimates suggest that an intervention is, on average, followed by a decrease of half a percentage point in the options-implied one-week volatility. However, the result is not statistically significant for the three-month implied volatility, which supports the idea that there is no strong statistical evidence to suggest that interventions always affect the whole structure of the volatility curve.

Table 11.4 also shows the effects of interventions over the options-implied skewness. However, in this case no statistically significant evidence exists to infer that this variable is affected by foreign exchange interventions.

Although the results found for the implied volatility are interesting and some of them statistically significant, Table 11.5 shows that they are not robust to estimating the same relationship using the first difference of the variables instead of the level of the variables. The coefficient on the effect of interventions on one-week volatility is not significant, and it is of the opposite sign of that in Table 11.4, again suggesting that the effect on volatility is only temporary.

Overall, the evidence suggests a negative effect, on average, of interventions on the options-implied, short-run volatility, which is consistent with the previous discussion. Interventions of different types, or in different periods, might have different effects, but the results suggest that central bank interventions affect markets in a way consistent with the stated objectives of improving the short-run functioning of the foreign exchange market.

MEASURING THE EFFECT OF INTERVENTIONS OVER THE DIFFERENT MOMENTS OF FOREIGN EXCHANGE DIFFERENCES, VOLATILITY, AND BID-ASK SPREAD DISTRIBUTIONS

Traditional approaches to assessing the effectiveness of foreign exchange interventions, such as the econometric model described earlier, measure the impact of interventions during the first moment of the foreign exchange distribution for several indicators, such as exchange rate levels, average volatility, or bid-ask spread

TABLE 11.4.

Effect of Interventions on the One-Week and Three-Month Options: Implied Volatility and Skewness of the Exchange Rate

Statistic	Maturity	Int_t	β_0	s_{t-1}	s_{t-2}	$CF\_CAD_t^j$	$CF\_LA_t^j$
Volatility	1-week	−0.5039	−0.3536	0.8867	−0.0664	0.0758	0.1717
	significance level	***	***	***	**	***	***
	3-month	−0.0469	0.0276	1.1827	−0.2253	0.0148	0.0322
	significance level			***	***	*	****
Skewness	1-week	0.0135	−0.0961	0.8211	−0.0315	0.1348	0.2167
	significance level		***	***		***	***
	3-month	−0.0047	−0.0258	0.8211	−0.0630	0.0356	0.1141
	significance level		*	***	**	***	***

Source: Bank of Mexico's estimates, using Thomson Reuters Worldscope data.
Note: The linear regression model is estimated for each statistic in terms of a dummy that takes the value of one, whenever an intervention took place, and zero elsewhere, for the first two lags of the statistic, as well as for two common factors ($CF\_CAD_t^j$ and $CF\_LA_t^j$). The first common factor corresponds to the contemporaneous statistic for Canada. The second common factor is calculated as the mean of the contemporaneous statistics for Brazil, Chile, Colombia, and Peru.
$*p < .1$; $**p < .05$; $***p < .01$.

TABLE 11.5.

Effect of Interventions on the First Difference of the Options: Implied One-Week and Three-Month Volatility and Skewness of the Exchange Rate

ΔStatistic	Maturity	Int_t	β_0	Δs_{t-1}	$CF\_CAD_t^j$	$FC\_AL_t^j$
Volatility	1-week	0.0700	−0.0040	−0.0289	0.3421	1.4846
	significance level			*	***	***
	3-month	0.0016	0.0030	0.0142	0.3421	1.2658
	significance level				***	***
Skewness	1-week	0.0011	0.0012	−0.0499	0.2893	1.6137
	significance level			**	***	***
	3-month	0.0070	0.0001	−0.0752	0.1896	1.2713
	significance level			***	***	***

Source: Bank of Mexico's estimates, using Thomson Reuters Worldscope data.
Note: The linear regression model is estimated for the first difference of each statistic in terms of a dummy that takes the value of one, whenever an intervention took place, and zero elsewhere for the first two lags of the first difference of the statistic, as well as for two common factors ($CF\_CAD_t^j$ and $CF\_LA_t^j$). The first common factor corresponds to the contemporaneous first difference of the statistic for Canada. The second common factor is calculated as the mean of the contemporaneous first differences of the statistics for Brazil, Chile, Colombia, and Peru.
$*p < .1$; $**p < .05$; $***p < .01$.

several indicators, such as exchange rate levels, average volatility, or bid-ask spread levels. However, these approaches do not look at the possible effects over the different moments of their respective distributions.

This section uses an approach based on the Mexican peso density functions related to the changes in the exchange rate, volatility, and liquidity to assess possible intervention effects that go beyond the first moment of the distribution.

Volatility Analysis Based on Intraday data for the Exchange Rate

Mexican peso volatility density functions four days before and four days after the day of the announcement of interventions were estimated using high-frequency intraday data and a Gaussian kernel approach. Although the comparison of these density functions shows that interventions have no significant effect on average volatility, they tend to reduce the presence of extremely high volatility before the policy actions. Figure 11.9 displays the density function of Mexican peso volatility during four days before and after the three kinds of interventions analyzed in the previous section: the announcement of US dollar auctions in December 2014 and March 2015, the implementation of two direct interventions in February 2016 and January 2017, and the announcement of the foreign exchange hedge auctions program.[8]

In each panel of Figure 11.9, the density function for the days before the interventions is depicted with a green line, and the density function for the days after the intervention with a blue line.

In some cases, the volatility density function seems to have a minor drift with no clear direction for assessing the net effect of interventions (similar to some of the results presented in the literature previously mentioned). Because, the counterfactual case for comparing the average volatility at a given point in time with and without foreign exchange interventions is not available, it is not possible to make a strong conclusion from the analysis. Nonetheless, most of the interventions seem to reduce the presence of extremely high volatility, which is shown in Figure 11.9 as the long right-hand tail of the Mexican peso volatility density function that disappears after the majority of the interventions.[9] Overall, the three intervention mechanisms analyzed seem to have a similar effect on volatility.

Liquidity Analysis Based on Intraday Data for Bid-Ask Spreads

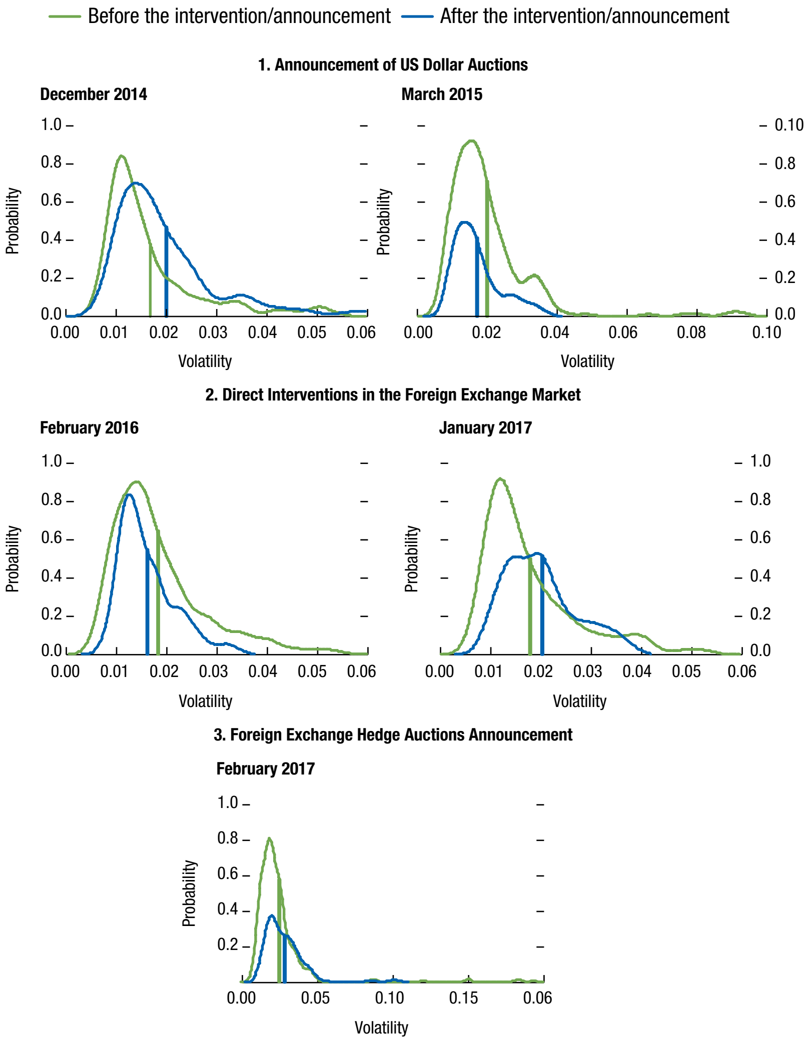
Another implication of foreign exchange interventions is their effect on market liquidity, as measured by bid-ask spreads. After all, central bank interventions aim to provide liquidity and to foster stable market operating conditions. For the Mexican peso, evidence suggests that interventions tend to prevent these spreads from increasing significantly, given that the relative scarcity of foreign currency is compensated by the central bank.

Analogous to the density function analysis for Mexican peso volatility, density functions for bid-ask spreads were estimated before and after each of the interventions mentioned above. The results, depicted in Figure 11.10, suggest the following:

[8] Intraday data is grouped every 15 minutes.

[9] The first and second moments of these distributions (mean and variance) were tested. In most cases, the test suggested a change in the distribution.

Figure 11.9. Mexican Peso Intraday Volatility Density Function, by Intervention



Source: Bank of Mexico's estimates, using Thomson Reuters Worldscope data.
Note: For all panels, the first and second moments of the distributions (mean and variance) were tested to compare the values before and after the policy actions for both episodes. For panels 1 and 2, a Welch's *t*-test was used to compare the means and prove that they were statistically different. For panel 3, a Welch's *t*-test was used to compare the means and prove that they were not statistically different. For panel 1, an *F*-test was used to demonstrate that the variances in December 2014 were not statistically different; however, in March 2015, the variances were proven to be different. For panels 2 and 3, an *F*-test was used to demonstrate that the variances were statistically different. Intervention day's data were eliminated to avoid momentary distortions because of this action. The vertical line shows the average of the observed data.

- In the announcement of US dollar auctions, the March 2015 event reduced the long right-hand tail of the bid-ask spread density function. However, the intervention of December 2014 coincided with an increase in the right-hand tail.
- The direct intervention in January 2017 slightly reshaped the density function, which reduced extreme values. However, evidence for the intervention of February 2016 does not show major changes in the distribution.
- The announcement of the foreign exchange hedge program in February 2017, despite reducing some extreme values, clustered more observations on the right side, which suggests an overall increase in bid-ask spreads.

The evidence is not clear whether interventions help reduce extreme values of the bid-ask spread.[10] However, given the lack of a counterfactual, it is difficult to claim categorically that interventions had no positive impact on the bid-ask spreads. Further analysis is required to confirm this preliminary evidence.

Kolmogorov-Smirnov Test for the Exchange Rate Volatility Distributions Based on Intraday Data

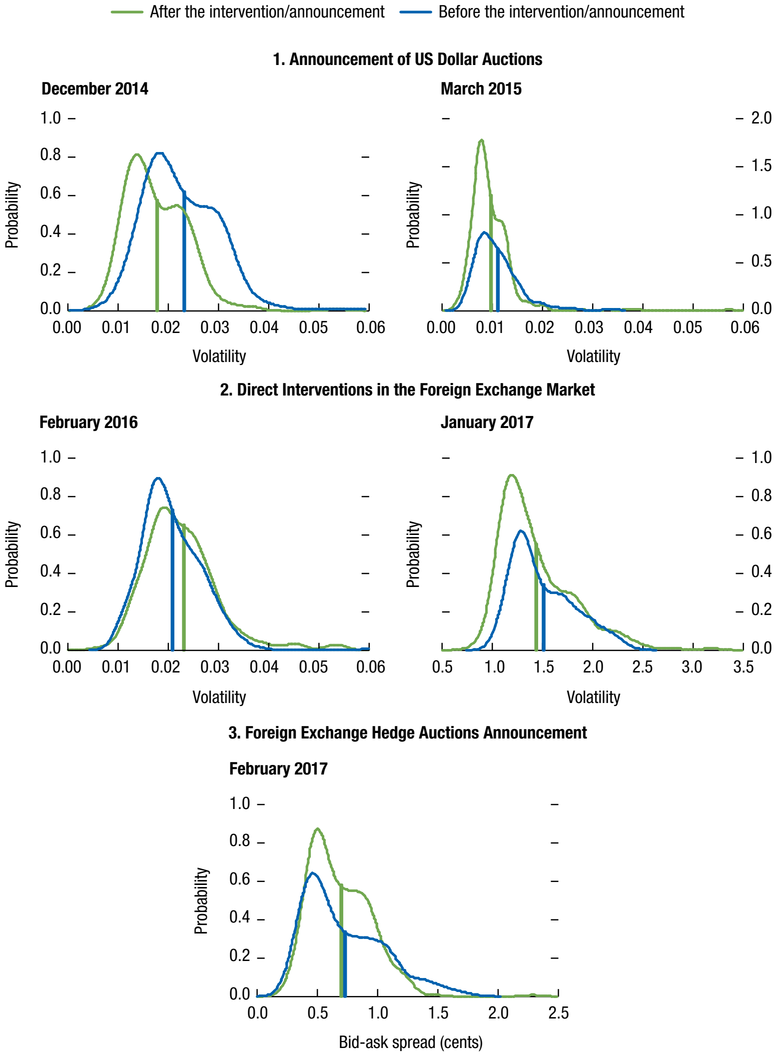
In line with previous sections, and using the same high-frequency intraday data, a two-sample Kolmogorov-Smirnov Test was performed to examine whether exchange rate interventions changed the distribution of the volatility of the Mexican peso. Table 11.6 summarizes the results when contrasting the null hypothesis $H_0\!:\!F_{prior}(\text{Vol}_{MXN/USD}) = F_{post}(\text{Vol}_{MXN/USD})$ vs. $H_a\!:\!F_{prior}(\text{Vol}_{MXN/USD}) \neq F_{post}(\text{Vol}_{MXN/USD})$, where $F_{prior}(\text{Vol}_{MXN/USD})$ and $F_{post}(\text{Vol}_{MXN/USD})$ correspond to the distribution of the volatility of the exchange rate for four days before and four days after each intervention, respectively. For the interventions considered, the Kolmogorov-Smirnov statistic is small when compared with the three critical values presented in four of the five interventions; therefore, the null hypothesis is not rejected in the majority of cases. With these results we can only confirm that the volatility of the exchange rate was modified with the direct intervention of January 2017.

Kolmogorov-Smirnov Test for the Bid-Ask Spread Distribution Based on Intraday Data

Similarly, a two-sample Kolmogorov-Smirnov Test was performed to examine whether exchange rate interventions changed the bid-ask spread distribution of the Mexican peso. Table 11.7 summarizes the results when contrasting the null hypothesis.

[10] For the bid-ask spread distributions, the first and second moments were tested in means and variance. Similar to volatilities, the test suggested a significant change in the distribution.

Figure 11.10. Mexican Peso Intraday Bid-Ask Spread Density Function, by Intervention Day, 2014–17



Source: Bank of Mexico's estimates, using Thomson Reuters Worldscope data.
Note: For all panels, the first and second moments of these distributions (mean and variance) were tested to compare the values before and after the policy actions. The intervention day's data were eliminated to avoid momentary distortions due to this action. The vertical line shows the average of the observed data. For panel 1, a Welch's *t*-test was used to compare the means and proved that they were statistically different. For panel 2, a Welch's *t*-test was used to compare the means, and in February 2016 proved that they were statistically different; however, in January 2017 they did not prove to be different. In panel 3, a Welch's *t*-test was used to compare the means and proved that they were not statistically different. For panel 1, an *F*-test was used to demonstrate that the variances in December 2014 were statistically different; however, in March 2015 the variances were proved not to be different. For panels 2 and 3, an *F*-test was used to demonstrate that the variances were statistically different.

TABLE 11.6.

Results for the Kolmogorov-Smirnov Test for the Difference in the Mexican Peso Distribution before and after Interventions

Type of Intervention	Intervention Date	Kolmogorov-Smirnov Statistic	Critical Values $a = 0.01$	$a = 0.05$	$a = 0.10$	Reject H_0?
Announcement of US dollar auction	December 2014	0.3333	0.4569	0.3812	0.3435	No
	March 2015	0.2188	0.4447	0.3711	0.3344	No
Direct intervention on the foreign exchange market	February 2016	0.1277	0.4037	0.3368	0.3035	No
	January 2017	0.3187	0.4143	0.3457	0.3115	Reject at 5%
Foreign exchange hedge auctions announcement	February 2017	0.2876	0.3949	0.3295	0.2970	No

Source: Bank of Mexico.
Note: Critical values are calculated as $c(a)\sqrt{\frac{m+n}{m*n}}$, where $c(a)$ corresponds to the inverse of the Kolmogorov distribution at a; and m, n correspond to the number of observations in the prior and post exchange rate data, respectively. Exact p-values are not available.

TABLE 11.7.

Results for the Kolmogorov-Smirnov Test for the Bid-Ask Spread Distribution of the Exchange Rate before and after Interventions

Type of Intervention	Intervention Date	Kolmogorov-Smirnov Statistic	Critical Values $a = 0.01$	$a = 0.05$	$a = 0.10$	Reject H_0?
Announcement of US dollar auction	December 2014	0.3458	0.1605	0.1339	0.1207	Yes
	March 2015	0.1718	0.1546	0.1290	0.1163	Yes
Direct intervention on the foreign exchange market	February 2016	0.1367	0.1410	0.1176	0.1060	Reject at 5%
	January 2017	0.1774	0.1405	0.1172	0.1056	Yes
Foreign exchange hedge auctions announcement	February 2017	0.1336	0.1375	0.1147	0.1034	Reject at 5%

Source: Bank of Mexico.
Note: Critical values are calculated as $c(a)\sqrt{\frac{m+n}{m*n}}$, where $c(a)$ corresponds to the inverse of the Kolmogorov distribution at a; and m, n correspond to the number of observations in the prior and post exchange rate data, respectively. Exact p-values are not available.

$H_0 : F_{prior}(\mathrm{Vol}_{MXN/USD_{B-A}}) = F_{post}(\mathrm{Vol}_{MXN/USD_{B-A}})$ vs. $H_a : F_{prior}(\mathrm{Vol}_{MXN/USD_{B-A}}) \neq F_{post}(\mathrm{Vol}_{MXN/USD_{B-A}})$, where $F_{prior}(\mathrm{Vol}_{MXN/USD_{B-A}})$ and $F_{post}(\mathrm{Vol}_{MXN/USD_{B-A}})$ correspond to the bid-ask distribution of the exchange rate for four days before and four days after each intervention, respectively. For the interventions considered, the Kolmogorov-Smirnov statistic is high when compared with the critical values presented; therefore, the null hypothesis is rejected in all cases at some level. These results confirm that exchange rate interventions modified the bid-ask spread distribution of the exchange rate.

some level. These results confirm that exchange rate interventions modified the bid-ask spread distribution of the exchange rate.

HOW TO INTERVENE

As noted, the FX Commission decides when to intervene in the foreign exchange market. Its considerations depend on the objective of the intervention. For example, if the Commission wants to accumulate additional international reserves or to reduce its pace of accumulation, then the obvious variable to look at is the stock of international reserves and to evaluate its marginal costs versus its marginal benefits.

If the decision is to provide liquidity to the market to ensure proper operating conditions and to temper the volatility of the exchange rate, then the variables to assess are those related to the operating conditions of the Mexican peso. Other variables, such as the real effective exchange rate or the nominal effective exchange rate, should also be considered. However, it is important to note that the FX Commission uses no single rule to decide the adequate time to intervene.

This section describes analytical tools the Bank of Mexico's staff has provided to the FX Commission to facilitate the decision process. First, it briefly describes some of the models used to assess the level of international reserves. Second, it looks at some of the metrics used to assess the operating conditions of the Mexican peso. Those metrics are used to calculate an index of operating conditions that clearly indicates those days of poor operating conditions.

MODELS TO ASSESS THE SUFFICIENCY OF INTERNATIONAL RESERVES

Bank of Mexico staff works with several indicators to assess the sufficiency of international reserves. As already mentioned, some of those metrics are (1) the ratio of reserves to GDP, compared to the ratio observed in other emerging markets; (2) the reserve adequacy metric proposed by Moghadam, Ostry, and Sheehy (2011) (the IMF metric); (3) cost-benefit approaches, such as the one proposed by Calvo, Izquierdo, and Loo-Kung (2012); and (4) utility-maximizing approaches, such as the one developed by Jeanne and Rancière (2006).

1. Ratio of international reserves to GDP: A straightforward metric used by rating agencies, market analysts, and the Bank of Mexico to judge how international reserves compare to other emerging market economies in terms of GDP. After the global financial crisis, this metric determined that the Bank of Mexico needed to accumulate more international reserves. Figure 11.11 shows how Mexico's reserves compared to other countries' reserves by the end of 2009.
2. IMF metric: This metric proposes a level of international reserves based on a weighted sum of variables related to potential US dollar outflows during periods of exchange market pressure. The metric considers that international

the stock of international reserves increased, reaching the middle point of the range suggested by the metric (Figure 11.12).

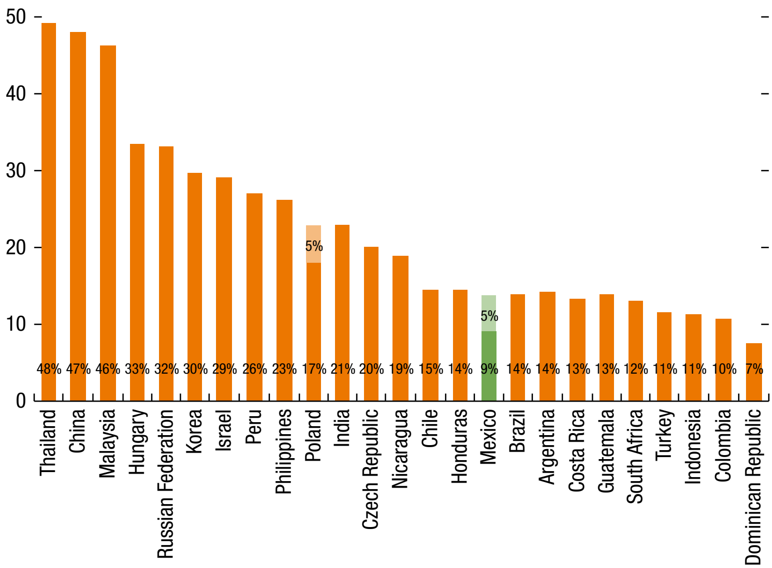
3. Cost-benefit approaches: Calvo, Izquierdo, and Loo-Kung (2012) propose an optimization approach that maximizes the benefits of holding international reserves subject to the costs that would arise under a sudden stop of capital inflows and the marginal cost of accumulating reserves (cost of carry). This metric shows that, in May 2003, when the mechanism to reduce the pace of accumulation of international reserves was put in place, the actual stock of reserves was above the level suggested by this model. Moreover, at the time the mechanism was put in place, the amount of US dollars Pemex was typically selling to the central bank was quite significant (see Figure 11.13).
4. When the put option mechanism was implemented after the "tequila crisis" of 1994–95, and after the global financial crisis, the actual stock of reserves (Figure 11.13) was below the level suggested by this model.
5. Utility-maximizing approach: The model proposed by Jeanne and Rancière (2006) determines the adequate level of reserves by maximizing the utility of a representative agent of the domestic economy during a sudden stop of capital inflow. This model is known as an extension of the Greenspan-Guidotti rule. It considers the total amount of short-term debt to calculate the sufficient level of reserves, as well as the potential drop of GDP during the sudden stop period and the cost of carry of holding international reserves. Figure 11.14 shows that the model has recently suggested a stock of reserves considerably above the one observed. However, once the resources from the flexible credit line with the IMF are considered, the stock of reserves seems appropriate. In view of the various approaches, the decision to buy or sell US dollars cannot be based on one single model or metric; even though this model may suggest higher reserves, it has to be put into perspective with the results from the other metrics.

METRICS TO ASSESS THE OPERATING CONDITIONS OF THE MEXICAN PESO

Given that the FX Commission has stated several times that the level of the exchange rate is not targeted, and that what matters is a liquid and well-functioning foreign exchange market, the Bank of Mexico's staff follows several indicators that reflect the operating conditions of the Mexican peso. The variables that reflect these conditions are (1) observed volatility of the Mexican peso; (2) skewness and kurtosis of the Mexican peso; and (3) bid-ask spreads, among other factors.

With those indicators, the bank's staff calculates an index that provides timely information about all trading and operating conditions of the foreign exchange market (hereafter referred to as the index of FX operating conditions). To calculate the index, each variable is normalized to its mean and a historical percentile is obtained. Then an index is constructed using the average of the percentiles

Figure 11.11. International Reserves at the End of 2009: A Country Comparison of Stocks
(Percentage of GDP)



Sources: Bank of Mexico; Haver Analytics; and National Institute of Statistics and Geography.
Note: The light sections of the bars indicate flexible credit lines with the IMF.

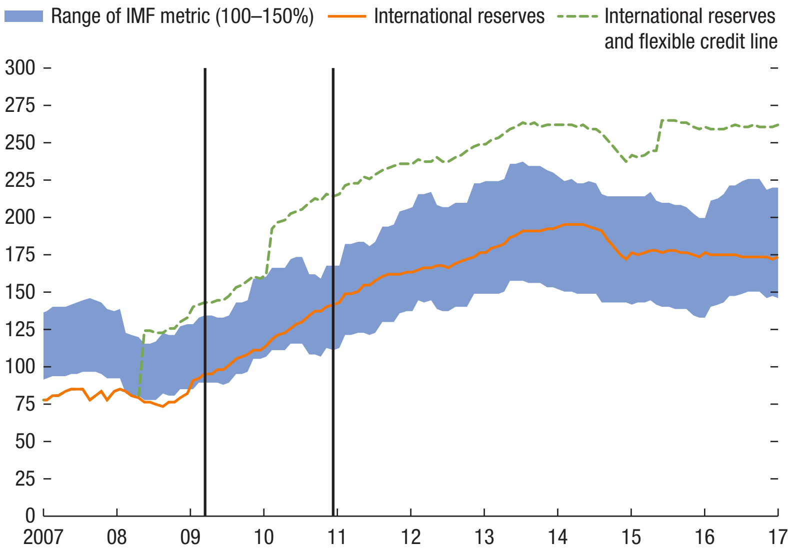
computed in the previous step. This information shows current conditions of the foreign exchange market and helps identify periods when the market is operating normally.

Figure 11.15 shows that in February 2016 and January 2017, the FX Commission instructed direct interventions, given that operating conditions of the foreign exchange market were deteriorating. The index is only one of many measures the FX Commission frequently uses to decide when to intervene.

PROCESS FOR DECIDING HOW MUCH TO INTERVENE

There is no specific rule that determines how much to intervene. For interventions to accumulate reserves or reduce the pace of accumulation of reserves, the amount is determined based on the objective for the stock of reserves. Given that those amounts tend to be relatively high, a rules-based mechanism is used to smooth the intervention through time and to avoid altering the liquidity conditions of the foreign exchange market (that is, a put options mechanism to accumulate international reserves or daily auctions without a minimum price to sell US dollars).

Figure 11.12. International Reserves and the IMF Metric, 2007–17
(Billions of US dollars)



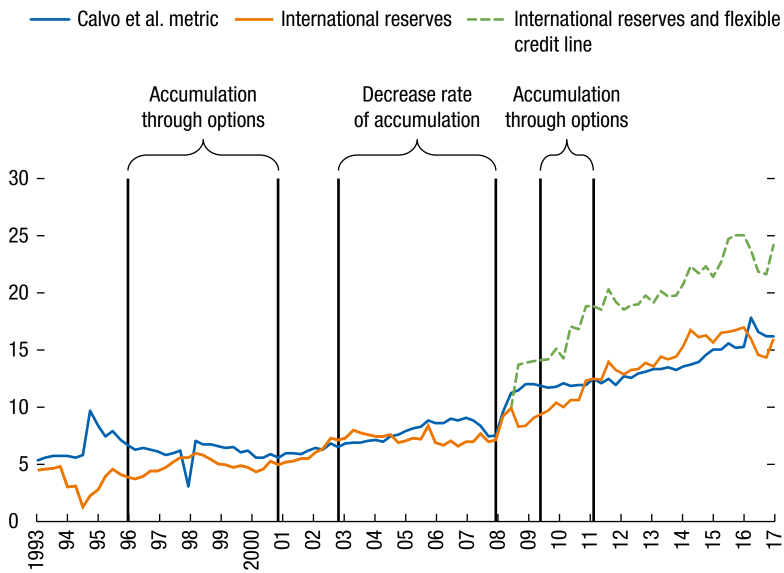
Sources: Bank of Mexico; and the National Institute of Statistics and Geography.

On the other hand, when the objective of the intervention is to provide liquidity to the market, decisions have been ad hoc. For example, in October 2008, the Bank of Mexico sold more than $6 billion in a single day. That number was based on market intelligence about the shortage of foreign exchange liquidity in the market during that day. In outright interventions to sell US dollars (February 2016 and January 2017), the amount was determined by taking into account the total daily turnover of the Mexican peso, and that it had to be large to send a strong signal to the market.

For daily auctions of US dollars with and without a minimum price, the amount is based on the potential amount of US dollars that would be sold during a particular period. Even though those mechanisms are usually announced through these mechanisms without a specific expiration date, the FX Commission keeps in mind the potential amount of US dollars that could be sold if the mechanism prevailed for several months.

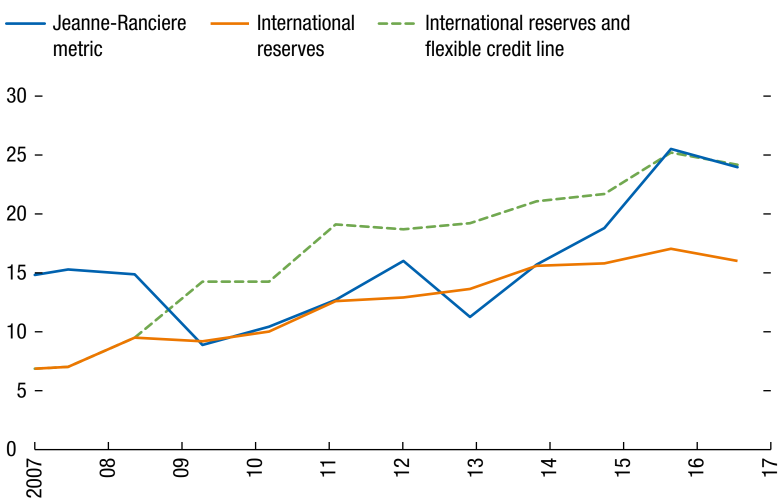
No specific rules determine the amount of foreign exchange interventions; the decision is taken on a case-by-case basis. The decision must consider liquidity conditions in the foreign exchange market and daily turnover of the Mexican peso, and the signal the FX Commission wants to send to the market, among other things.

Figure 11.13. International Reserves and the Calvo and Others' Metric, 1993–2017
(Percentage of GDP)



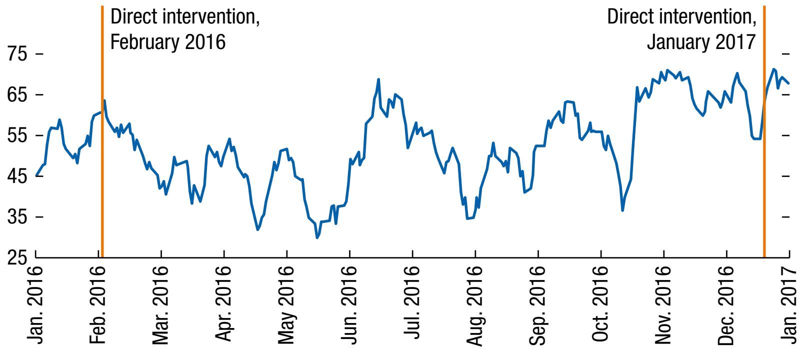
Source: Bank of Mexico.

Figure 11.14. International Reserves and Jeanne-Rancière Metric, 2007–17
(Percentage of GDP)



Sources: Bank of Mexico; and the National Institute of Statistics and Geography.

Figure 11.15. Index of Foreign Exchange Market's Operating Conditions, 2016–17
(Five-day moving average)



Source: Bank of Mexico, using Thomson Reuters Worldscope data.
Note: The index presents higher values when the operating conditions are deteriorated.

INTERVENTION POLICY COMMUNICATION

When considering intervention policy communication and transparency, several views should be considered:

1. Chiu (2003) concludes that the benefits of transparency (enhancement of policy effectiveness, strengthening of governance by promoting accountability, signaling, and reduced speculation, among others) in foreign exchange interventions appear to outweigh the risks (erosion of credibility if interventions fail to achieve their objective, reduced ability to surprise speculators, impression of distress by market participants and the public).
2. On the other hand, Chutasripanich and Yetman (2015) remark that adding an element of "opaqueness" to foreign exchange interventions tends to reduce the size of speculative flows and the cost of carrying reserves, despite increasing volatility in exchange rates, current account balances, and reserves.

Since December 1994, the Bank of Mexico has been very transparent in its foreign exchange interventions. In fact, all interventions are communicated to the public through its website.[11] For the majority of interventions, information is available on amounts, dates, and reasons for intervention. Every intervention is accompanied by a press release from the FX Commission in which it clearly explains the intervention (objective, amounts, operating details, and so on).[12] It is only when a discretionary intervention takes place, that the press release will omit specific details, such as amounts. However, the amount of the intervention

[11] FX Commission bulletins are available in Spanish at http://www.banxico.org.mx/informacion-para-la-prensa/comunicados/politica-cambiaria/comision-de-cambios/index.html.

[12] Most of the press releases are published at the same time of the intervention. When the intervention is a rules-based mechanism, the press release comes before the intervention.

can be inferred ex post from the information published in the weekly financial statement of the central bank. In that report, the stock of international reserves is presented with the weekly flows, and it breaks down the factors that explain the changes (market interventions).

In addition, from all the information the FX Commission makes public, and the operating conditions index the central bank publishes every now and then in its minutes for monetary policy decisions or in other reports, it is relatively predictable when the central bank may act. Sometimes, before an intervention, market analysts begin to report that a Bank of Mexico intervention is likely. However, they do not precisely predict the size or timing.

THE MAIN LESSONS FROM MEXICO

The main lesson from more than 20 years of intervening in the foreign exchange market under a flexible exchange rate regime, and from interventions before the free-floating regime, is that there is no use targeting a specific level for the exchange rate. All interventions by the Bank of Mexico are respectful of the floating regime, and the prices at which they are conducted are either auction-based, or they are closed for discretionary direct interventions and consider prevailing market prices.

Preannounced mechanisms are preferred over interventions without previous notice, but the discretion to use the latter should always be considered when circumstances warrant it. In this regard, market participants, who understand the settings of the prevailing mechanism, have, on a few occasions, played with the rules to manipulate the exchange rate in an undesirable way. In those circumstances, an extraordinary measure or change of mechanism would take place.

No unique tool fits all situations. Even if the main objective of the intervention is the same in two different episodes, the different conditions can call for different tools. Regarding the objectives of foreign exchange intervention, it is difficult to statistically prove the effectiveness of an intervention, as measured by its effect on market operating conditions, because intervention counterfactuals are unknown. The FX Commission has therefore been careful to limit interventions to episodes in which they are deemed extremely necessary. Transparency has always been a good policy; it is important that markets and the public are informed of any type of intervention as long as it does not weaken its effectiveness.

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CHAPTER 12

Peru: Foreign Exchange Intervention under Financial Dollarization

Adrian Armas and Marco Vega

This chapter explores the case for foreign exchange intervention in Peru. The Central Reserve Bank of Peru abandoned the exchange rate peg in August 1990 and moved to a managed floating exchange rate regime. Since its inception, the floating regime has been subject to intervention by the central bank to smooth out exchange rate volatility. One key element of the motivation by the Central Reserve Bank of Peru to intervene in the foreign exchange market is the fact that Peru has a high degree of financial dollarization, although on a clearly decreasing path. The Peruvian case provides a long experience of discretionary-type intervention, based on daily assessments of foreign exchange market conditions. This type of intervention has enabled the Central Reserve Bank of Peru to run a countercyclical monetary policy, in particular, during critical periods such as the global financial crisis and the latest episode of quantitative-easing tapering that coincided with a strong fall in commodity prices (2013–15).

INTRODUCTION

Foreign exchange intervention by emerging market central banks has been a key policy issue in recent decades, especially as these banks have increasingly adopted managed floating exchange rate regimes, moving away from fixed or pegged regimes. This was also true in Peru.

After two major financial crises—the 1997–98 crisis that hit emerging market economies and the 2008 global financial crisis—foreign intervention policies have endured in emerging markets. This fact has renewed analytical interest in academic circles, which had neglected intervention policies because of scant evidence on their effectiveness in developed countries and their theoretical irrelevance in a world of perfect capital mobility (Backus and Kehoe 1989).

The new academic literature instead assumes imperfect capital mobility, as advanced by Cavallino (forthcoming) or Fanelli and Straub (2018), for example. These two reports suggest that optimal intervention policies “lean against the

The opinions expressed in this chapter are the sole responsibility of the authors and are not necessarily those of the Central Reserve Bank of Peru.

wind," which is tantamount to reducing exchange rate volatility.[1] Recent evidence on central bank intervention supports these theoretical findings; for example, Daude, Levy-Yeyati, and Nagengast (2016) and Fratzscher and others (2019) provide important evidence on the effectiveness of foreign exchange interventions, and that smoothing exchange rates is the main objective of intervention in emerging market economies.

This chapter examines the Peruvian case of more than 25 years of sterilized foreign exchange intervention under a managed floating exchange rate regime. It delves into issues such as the rationale of Peruvian central bank intervention within its overall monetary policy framework, the discretionary and high-frequency intervention implementation, existing evidence about its effectiveness, and the optimality of leaning-against-the-wind intervention in the face of uncertainty regarding shocks.

The next section explores the policy background and explains the rationale for foreign exchange intervention. The chapter then assesses evidence for the effectiveness of central bank foreign exchange intervention, followed by intervention procedures in Peru, and concluding remarks.

A MANAGED FLOAT SINCE 1990

Peru has run a managed floating exchange rate regime since 1990. In August 1990, a series of liberalization reforms was the onset of a stabilization process. The reforms were put in place to tame hyperinflation and reverse a dramatic output collapse that had started in the mid-1970s. The Central Reserve Bank of Peru was first among the region's central banks (along with the Central Bank of the Dominican Republic) to abandon its pegged exchange rate regime.

During the 1970s and 1980s (and earlier), Peru had many exchange rate pegs, a heavily controlled multiple exchange system, and a closed financial system.

From August 1990 to December 1991, monetary authorities abandoned all exchange controls, restored full convertibility, liberalized current and capital accounts, and established a managed floating exchange rate regime.

Unlike other inflation stabilization episodes, Peruvian stabilization was based on the strict control of monetary aggregates. To make the central bank credible, it was crucial to grant it full independence and to break free of the fiscal dominance of policy that was prevalent in the two previous decades. This meant, for example, that any form of central bank credit to the government was forbidden. At the time, exchange rate–based stabilization was ruled out because of the

[1] When foreign exchange intervention seeks to slow exchange rate changes, but does not target levels, it is labeled as a policy that "leans against the wind," a term that first appeared in Branson (1976) to describe how advanced economies managed their exchange rate regimes after they started floating in 1973.

scarcity of international reserves, and because a series of exchange rate–based stabilizations had failed in the 1980s.[2]

When the 1990s began, reserves were almost depleted. After the stabilization, the central bank was committed to remonetize the economy after a fall in the demand for domestic currency and currency substitution during hyperinflation. During and after inflation stabilization, a natural way of remonetizing was the purchase of foreign currency through direct spot interventions. As long as stabilization was credible, the increasing domestic currency demand reflected a private sector portfolio shift from foreign to domestic currency. At that time, given that the stabilization program was based on avoiding internal borrowing by the central government, no other liquid assets were available that were suitable for monetary operations, including traditional sovereign bonds.[3]

Nonetheless, building monetary policy credibility was a slow and steady process: it took all of the 1990s to bring inflation down to international levels. This disinflationary process through the control of money aggregates was impaired by increasing instability in the relationship between monetary aggregates and inflation.[4]

Despite the reduction of inflation levels, dollarization remained high, as other conditions were not yet in place at the time (such as anchoring long-term inflation expectations by adopting an inflation-targeting regime).[5] Figure 12.1 shows the high degree of dollarization in the banking system during the 1990s. It is important to note that firms both in the tradable and nontradable sectors had dollarized assets and liabilities, and in most cases, the currency mismatch was high. In addition, an important share of government debt was denominated in US dollars.

The existence of financial vulnerabilities resulting from currency mismatches called for intervention to (1) accumulate reserves to provide international liquidity when needed, and (2) minimize sharp and unexpected exchange rate depreciations, which would bring about deleterious effects of currency mismatches in the economy.

Figure 12.2 describes the evolution of net international reserves and the behavior of the Peruvian nuevo sol (sol hereafter) during the 26 years since 1992, after hyperinflation. The figure shows the massive growth of international reserves, from virtually zero to around $60 billion. Shaded areas in the figure depict episodes of falling reserves—which are tantamount to periods of foreign capital outflow and exchange rate depreciation.

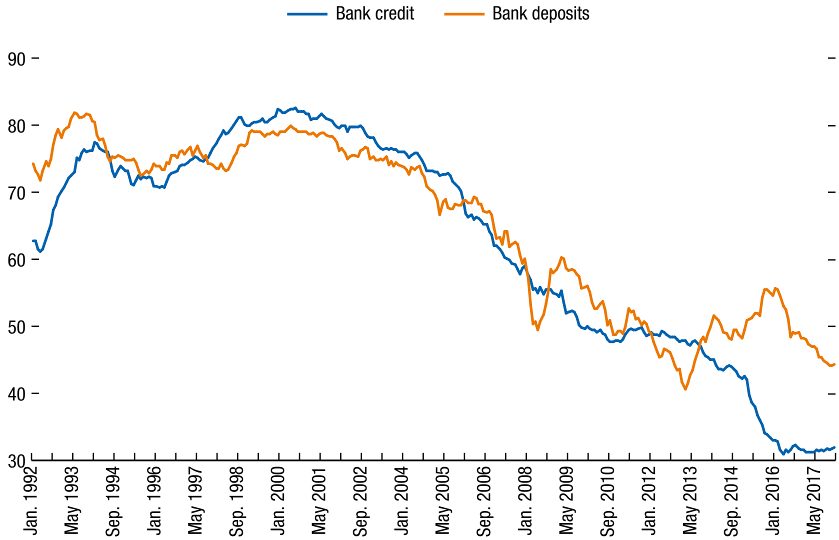
[2] Velarde and Rodríguez (1992) detail Peru's stabilization program to defeat hyperinflation.

[3] Armas and others (2001) detail the evolution of monetary instruments and the development of the interbank market in Peru.

[4] See Rossini and Vega (2008) for an account of the use of monetary aggregates during the disinflationary period.

[5] Armas and Grippa (2005) review the adoption of inflation targeting amid high dollarization.

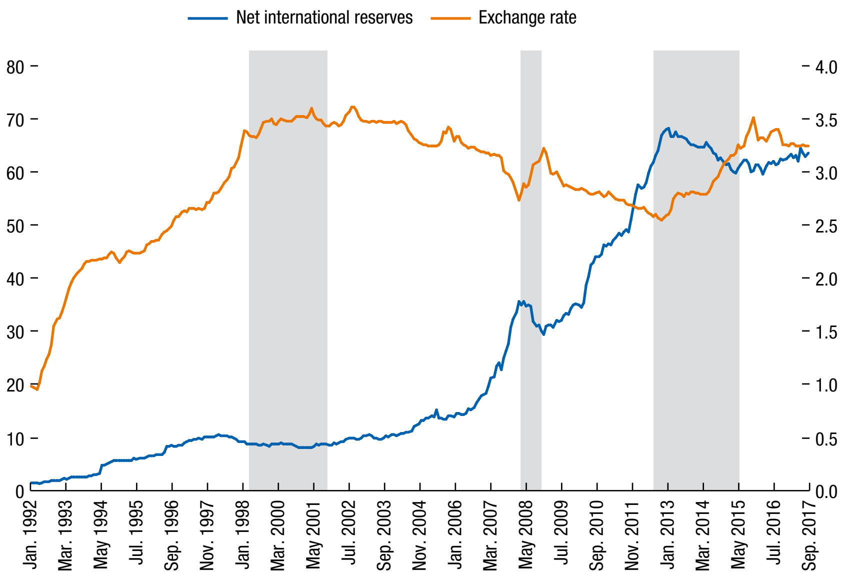
Figure 12.1. Dollarization of the Banking System, 1992–2017



Source: Central Reserve Bank of Peru.

Figure 12.2. Net International Reserves and the Peruvian Sol/US Dollar Exchange Rate, 1992–2017

(Billions of US dollars, left scale; Peruvian sol/US dollars, right scale)



Source: Central Reserve Bank of Peru.

This episode of initial international reserve accumulation ended in mid-1998 with the advent of a series of financial and other crises that affected emerging market economies across the globe: the Asian crisis in 1997, an extreme El Niño phenomenon in Peru in early 1998, and the Russian default in September 1998. The latter was the most damaging of these negative shocks, as it brought sudden, short-term capital outflows that froze the credit market and forced the closure or merging of half of the banking system.[6] The exchange rate depreciated 18 percent from June 1998 to September 1999, producing a strong contraction in an economy with 82 percent of loans denominated in foreign currency (Figure 12.1).

The other shaded areas in Figure 12.2 correspond to the global financial crisis of 2008–09 and the period of monetary policy tapering in the United States, which started with the taper tantrum in May 2013. During the global financial crisis, the sol depreciated 18 percent; during the tapering period, it depreciated as much as 35 percent (Table 12.1).

During these periods of volatility induced by global forces, foreign exchange interventions had been important to moderate excess fluctuations in the exchange rate. The key rationale for intervention was the avoidance of financial vulnerabilities stemming from the heavy dollarization of the financial system.

The literature on financial stability points to the exchange rate as a key asset price that can trigger financial crises.[7] As such, foreign exchange intervention to tame exchange rate volatility has been part of monetary policy design and requires high international reserves to allow purchases or sales on demand. In tranquil times, with capital inflows, purchases of foreign currency can dampen currency appreciation, and at the same time, build international reserves for harder times.

High international reserves have allowed more active foreign exchange interventions to face negative external shocks, such as the global financial crisis, US monetary policy tapering, and the sharp decline of commodity prices around this period (which continued until February 2016).

A remarkable period of intervention started in 2003 and ran through 2007, when US dollar purchases reached 9.6 percent of GDP (Figure 12.3). This unprecedented reserve accumulation was abruptly followed by the global financial

[6] Before the 1990s, the typical economic crisis was the result of extreme expansionary fiscal policies under pegged exchange rate regimes, so the classical path of losing international reserves with twin deficits ended up with an exchange rate collapse. The shock of 1998 was new for the Peruvian economy as it initially did not result from loose fiscal policy, but rather from high short-term external leverage that commercial banks had built after the Brady debt relief agreement of March 1997. See Castillo and Barco (2008) for details of this episode and an assessment of economic policy responses, as well as a regional comparison. The main conclusion of that paper was that the Peruvian economy suffered less than most of the economies in Latin America, despite high financial dollarization. The former finding did not preclude the Central Reserve Bank of Peru from making important improvements in the design of monetary policy (formal adoption of an inflation-targeting framework in 2002 and building of international reserves) that put it in a better position to face the next strong negative shocks of this century.

[7] See Eichengreen and Hausmann (1999) and the references therein.

TABLE 12.1.

Selected Episodes of Foreign Exchange Intervention

	Emerging Market Spillover Crisis (Asia, Russian Federation) and El Niño Phenomenon	Global Financial Crisis	Tapering and Strong Fall of Commodity Prices
Year of initial shock	1997	2008	2013
Depreciation	18% (Jun. 1998–Sept. 1999)	18% (Apr. 2008–Feb. 2009)	35% (Apr. 13–Feb. 2016, 34 months)
Credit dollarization	82%	52%	42%
Average GDP growth during shock and 1 year later	2.5% (1997–2000)	6.2% (2008–10)	3.9% (2013–16)
Net purchases of international reserves 1 year before initial shock	2.9% of GDP (1996)	7.1% of GDP (2007)	44.4% of GDP (2012)

Source: Central Reserve Bank of Peru.

crisis. Intervention was so large that it averted a recession that, otherwise, would have been like the one during the 1998–99 emerging economies crises.

Because figures represent yearly flows, they mask a huge selling period from June 2008 to February 2009. In that time, $7.1 billion (about 6 percent of 2009 GDP) were sold to avoid triggering negative balance sheet effects. After the global financial crisis, capital inflows and reserve accumulation resumed, which ended by the reversal of capital flows brought about by the tapering of quantitative easing in the advanced economies.

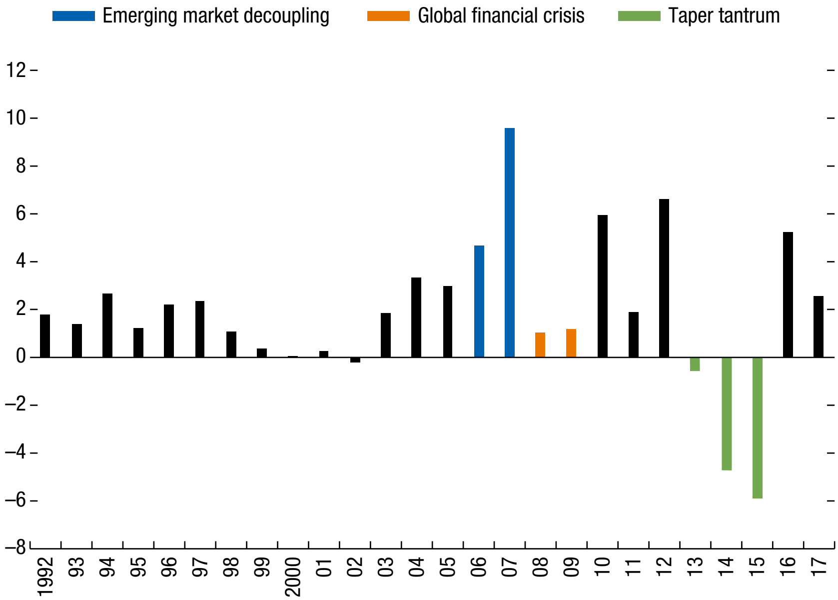
That tapering period is another remarkable episode of leaning against depreciation winds, with interventions of almost 5 and 6 percent of GDP in 2014 and 2015, respectively.

Overall, the long history of intervention episodes in Peru shows distinct features. In the early 1990s, a key driver of intervention was the accumulation of international reserves, which primarily reflected domestic currency remonetization. The period ends with the financial crisis in the emerging market economies at the end of the 1990s. Thereafter, a period of capital inflows into emerging markets took place; as a result, sizable international reserves were accumulated. In this period, US dollar purchases had a precautionary motive—that is, the increase of buffer stocks to face capital flow reversals.

MOTIVATION FOR INTERVENTION

The Central Reserve Bank of Peru follows an inflation-targeting regime in conducting its monetary policy. In other words, it uses its main policy interest rate to

Figure 12.3. Net Purchases of US Dollars, 1992–2017
(Percent of GDP)



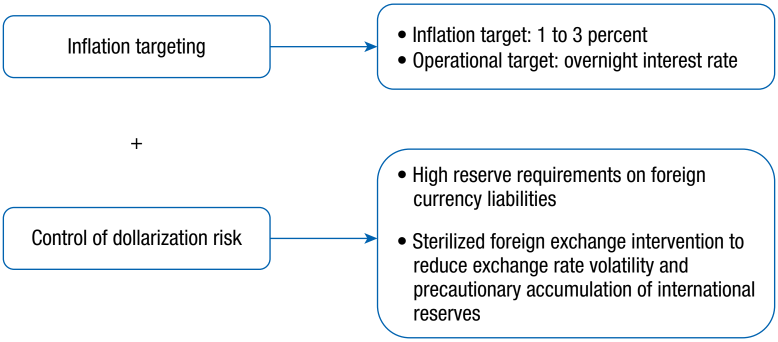
Source: Central Reserve Bank of Peru.

gear the inflation rate toward the inflation target. Inflation targeting is flexible in the sense of Svensson (2000), because it allows deviations from the inflation target whenever shocks do not move long-term inflation expectations away from target. These instances occur, for example, when short-lived supply shocks hit. Failing to conduct flexible inflation targeting would mean unnecessary output volatility.

The monetary policy framework considers the dynamics of output and its macroeconomic determinants. Financial dollarization is a key force behind the contractionary effects of exchange rate depreciation. In short, the contractionary effects are due to currency mismatches in the balance sheet of nontradable firms and households. Sometimes these contractionary effects can be larger than the usual textbook expenditure-switching effects, which are expansionary. Periods of sharp and large depreciation can imply overall contraction, because of large-scale balance sheet effects.

As such, monetary policy design includes a set of tools to control dollarization risks in a financially vulnerable economy (Figure 12.4). One of these tools is sterilized foreign exchange intervention, which induces high-frequency portfolio shifts across currencies, but it does not affect the level of domestic currency liquidity consistent with the policy rate. By reducing exchange rate volatility,

Figure 12.4. Monetary Policy Framework in Peru



Source: Central Reserve Bank of Peru.

foreign exchange intervention minimizes the risk of triggering perverse balance sheet effects, which would otherwise unleash excess output volatility.

Actions and communication by the central bank have allowed agents to understand the monetary policy design—in particular, the distinction between policy rate moves for inflation forecasting and foreign exchange intervention to smooth exchange rate volatility at high frequencies.

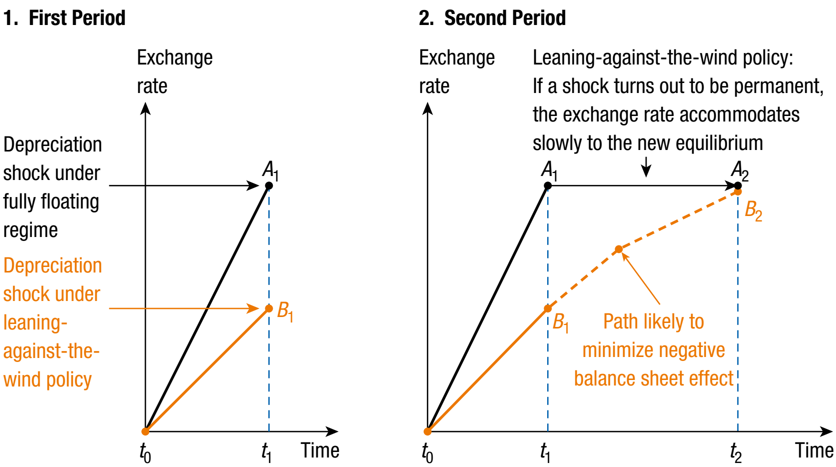
There are other ways to frame monetary policy design in Peru, apart from the usual flexible inflation-targeting regime. For example, it is said that monetary policy is usually made in a highly uncertain environment, and monetary policy should therefore respond not only to the most likely outcome but also to risk scenarios.

In Peru, the risk management approach is based on uncertainty about dollarization risks. To avoid low risk and the potentially damaging outcomes arising from balance sheet effects, the central bank uses sterilized foreign exchange interventions, as depicted in Figure 12.4.

Two main points arise in the conduct of such risk management policy. First is the usual moral hazard discussion. By intervening, the central bank provides public insurance, which induces private agents to take even more risks or to not seek private sources for hedging their financial risks. It is important to highlight that any policy option taken by central banks is seldom neutral: it is often argued, for example, that by reducing interest rates, monetary authorities induce more risk taking by banks. The approach of the Central Reserve Bank of Peru has been to foster hedging alternatives, mostly at the micro level, but to never neglect its macroeconomic stability mandate.

A pure free float is probably not credible for a central bank in an economy with high currency mismatches, because monetary policy always wants to avoid extreme risks to the economy (a lesson from the global financial crisis). As the extent of currency mismatches declines, the exchange rate could become more

Figure 12.5. External Shock Impact, Fully Floating and Leaning-Against- the-Wind Policies, and Persistent Shock



Source: Authors' design.
Note: There is uncertainty on the contractionary or expansionary nature of depreciation and on the shock duration. Policy responses are A_1 ("fully floating") or B_1 ("leaning against the wind").

flexible (point B_1 closer to point A_1 in Figure 12.5); however, this process of diminishing currency mismatches will take time.

The second point in the risk management framework relates to the accumulation of enough international reserves to conduct intervention operations of either a positive or negative sign. High international reserves overcome a key problem that financially dollarized economies face—namely, the absence of a lender of last resort denominated in US dollars. Therefore, high international reserves provide a self-insurance mechanism to the economy. Like any insurance mechanism, its optimality depends on policymakers' risk aversion, the history of balance of payments crises, and the shortage of international liquidity. In Peru, monetary authorities have taken a conservative approach to reduce the risk of economic crises, given the historical lessons delivered by economic setbacks of the past, in particular, hyperinflation and the full loss of international liquidity at the end of the 1980s.

In the Peruvian case, the argument for foreign exchange intervention to face episodes of real exchange rate misalignment has not been relevant. Only two episodes of important misalignment have occurred in the past 25 years. The first was observed before the financial crises in emerging market economies during 1997–98 and the second before the taper tantrum in 2013.

The overall perspective of risk management uses a set of tools summarized in Table 12.2. Both high international reserves and foreign exchange interventions

TABLE 12.2.

Macro Risk Management Tools

Types of Policies	Internalizing Risks	Dampening Shocks	Confronting Shocks
High reserve requirements on US dollar liabilities	Yes	Yes	Yes
High international reserves		Yes	Yes
Foreign exchange intervention		Yes	Yes

Source: Central Reserve Bank of Peru.

are used to dampen shocks (ex ante) and confront shocks (ex post) in the face of risk or crisis events.

When a shock hits, it is uncertain whether it is transitory or permanent. The history of shocks can reveal the normal ups and downs in prices and quantities, but it is not a good guide for disruptive financial crises, which, almost by definition, are unforecastable. Therefore, foreign exchange interventions that lean against the wind may be optimal for a financially dollarized economy.

To illustrate leaning against the wind, Figures 12.5 and 12.6 show a case of negative external shock, such as a taper tantrum or falling terms of trade. Point A_1 in Figure 12.5, panel 1, is the result of a depreciation in the fully floating case. The lower point, B_1, is the result of a leaning-against-the-wind policy. When the shock hits, there is uncertainty not only about the duration of the shock (permanent versus transitory) but also about whether exchange rate depreciation is expansionary or contractionary.[8]

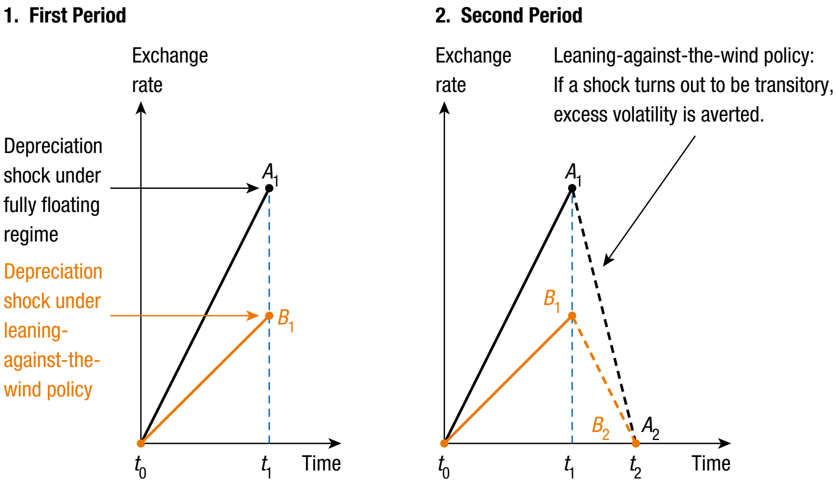
If the shock turns out to be permanent, the exchange rate would remain at point A_2 in the future, as depicted in panel 2. Leaning against the wind means that the exchange rate will eventually achieve this A_2 level, but at a slower pace. The small cost of the leaning-against-the-wind policy is that the exchange rate is not working as quickly as a shock absorber provided by the fully floating case. However, the benefit may be strong, because the central bank avoids triggering harmful balance sheet effects.

The lower exchange rate change to B_1 brought about by foreign exchange intervention depends, of course, on the effectiveness and extent of intervention. In turn, the size of intervention depends on the assessment of the shock; is it perceived as permanent or transitory? How mismatched are household and firm balance sheets? How fundamental is the shock? Floating exchange rates also tend to overshoot, not only for the reasons described in Dornbusch (1976) on the adjustment of sticky prices but also because of agents' panics and irrational exuberance.[9]

[8] Reports such as Galindo, Panizza, and Schiantarelli (2003); Céspedes, Chang, and Velasco (2004); Cook (2004); Bleakley and Cowan (2008); and An, Kim, and Ren (2014), among others, provide theoretical and empirical discussions of the expansionary or contractionary effects of exchange rate depreciations.

[9] The Dornbusch overshooting model considers rational expectations.

Figure 12.6. External Shock Impact, Fully Floating and Leaning-Against- the-Wind Policy, and Transitory Shock



Source: Authors' design.

Therefore, the passage from point B_1 to B_2 (equal to A_2) lets the exchange rate achieve its new fundamental equilibrium, but slowly, avoiding unnecessary jumps that may wreak havoc within a financially dollarized economy.

On the other hand, if the shock turns out to be transitory, the exchange rate would return to the pre-shock level depicted in Figure 12.6. Here the cost of the leaning-against-the-wind policy is zero, because there is no need for the exchange rate to work as a shock absorber. Nevertheless, the gain can be sizable, because the central bank avoids excess volatility.

Regarding the overall policy framework, the central bank monetary policy analysis made through its formal quantitative model takes into account the aforementioned causes and effects.[10] For example, the evolution of the exchange rate considers equations such as

$$s_{t,t+1} = \left(1 - c_e\right) E_t[s_{t+1}] + c_e s_{t-1} \tag{12.1}$$

and

$$i_t = i_t^* + \left(s_{t,t+1}^e - s_t\right) + \text{prem}_t + \xi_t, \tag{12.2}$$

where $s_{t,t+1}^e$ is the expectation of the next-period $(t + 1)$ exchange rate based on information available in the current period. However, this expectation is not purely rational. Instead, it comprises a fully rational component ($E_t[s_{t+1}]$) and an inertial component (s_{t-1}). Agents know that the central bank is always up for

[10] See Winkelried (2013) for the latest version of the Quarterly Projection Model.

intervention whenever an important shock hits and see that the size of intervention is large relative to market turnover; therefore, the evolution of the exchange rate is well explained by sluggish expectations, as shown in equation (12.1). Parameter c_e measures how effective and important foreign exchange interventions are to induce inertia in exchange rate expectations.

In equation (12.2), i_t is the domestic policy rate, i_t^* is the foreign policy rate, $prem_t$ is the risk premium that corresponds to assets denominated in domestic currency, and ξ_t is a shock to the nonarbitrage equation.

When equation (12.2) is solved forward, and exchange rate expectations are substituted by equation (12.1), the spot exchange rate s_t depends on its past value and the rational expectations of current and future interest rate differentials, current and future values of risk premiums, and current and future values of shocks. Again, the higher the c_e, the more inertial the spot exchange rate.

On the other hand, the assessment of the effects of exchange rates relies heavily on the evolution of the output gap:

$$y_t = \cdots + \alpha_{qm}(q_t^m) - \alpha_{qb}\left(\Delta q_t^b\right) + \cdots , \tag{12.3}$$

where y_t is the output gap relative to trend GDP, q_t^m is the effective multilateral real exchange rate gap, and Δq_t^b is the bilateral (relative to the United States) exchange rate depreciation. We abstract from all remaining terms in the output gap equation. Equation (12.3) shows the standard expenditure-shifting effect associated with a higher effective real exchange rate, together with the negative balance sheet effect linked to the bilateral real exchange rate depreciation.

If parameter α_{qb} is small relative to α_{qm}, then the overall effect of an exchange rate depreciation is positive. In contrast, when α_{qb} is large, the overall contractionary effect prevails. Furthermore, it is possible to have nonlinearities in the above equation if α_{qb} is a time-varying parameter that depends on exchange rate jumps. If the exchange rate change is small, α_{qb} may also be small and constant, but when the jump is large, α_{qb} may also change to a higher level.

Overall, the overarching motive for foreign exchange intervention in Peru is to avoid excess exchange rate volatility that would trigger negative financial and real effects in the economy.

EFFECTIVENESS OF INTERVENTION

Following the lean-against-the-wind approach explained in the previous section, a first glimpse of the effectiveness of intervention compares the sol with other currencies in the region.

Figure 12.7 shows the evolution of the Peruvian sol, together with the Brazilian *real* and the Colombian peso, all against the US dollar. The sol and the *real* are on the left axis because of their comparable levels; the peso/US dollar are on the right. These currencies tend to move in the same direction because of global factors. The sol moves concurrently with other currencies but at a milder pace, suggesting that daily intervention operations effectively influence the daily spot rate.

TABLE 12.3.

Appreciation and Depreciation of Currencies at Comparable Episodes
(Cumulative percentage changes)

	Peruvian sol	Brazilian *real*	Colombian peso	Chilean peso
Appreciation up to decoupling	−23.5	−55.7	−37.2	−37.6
Depreciation during global financial crisis	15.0	50.7	46.8	47.1
Appreciation after global financial crisis	−16.2	−15.0	−26.4	−26.4
Depreciation during tapering	30.4	99.1	77.5	50.5

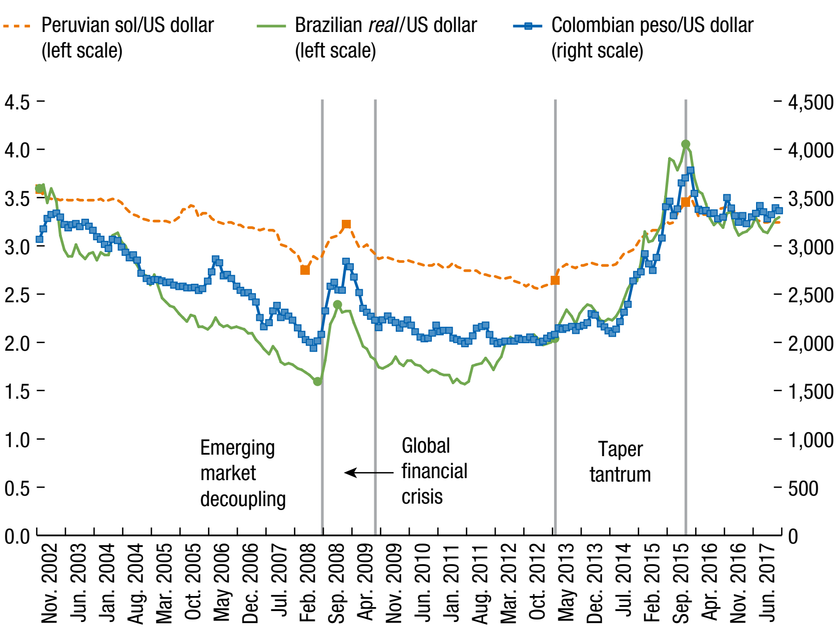
Sources: Central banks of Brazil, Chile, Colombia, and Peru.

The smoother sol/US dollar path can be verified by computing cumulative changes during the different episodes of the past 15 years (Table 12.3). As can be seen, Peru's cumulative appreciation or depreciation rates have been much lower.

As explained, the particular path of the sol/US dollar is consistent with a foreign exchange rate intervention for financial stability to avoid excess exchange rate volatility given currency mismatches.

In sum, the sol exchange rate does tend to move with other currencies (also shown in panel 1 of Table 12.4), but it does so with lower variability (panel 2 in Table 12.4). This result is the direct product of foreign exchange intervention.

Figure 12.7. Evolution of the Peruvian, Brazilian, and Colombian Currencies, 2002–17



Sources: Central banks of Brazil, Colombia, and Peru.

TABLE 12.4.

Measures of Correlation and Variability of Currencies

1. Correlations of Currency Levels					2. Measures of Currency Variability		
	1	2	3	4		Coefficient of Variability Levels	Standard Deviation of Percent Changes
1. Peruvian sol	1.00	0.74	0.87	0.78	Peruvian sol	9	1.2
2. Brazilian *real*		1.00	0.93	0.91	Brazilian *real*	26	3.8
3. Colombian peso			1.00	0.91	Colombian peso	19	3.2
4. Chilean peso				1.00	Chilean peso	13	2.7

Sources: Central banks of Brazil, Chile, Colombia, and Peru.

Before turning to the empirical evidence for the effectiveness of Central Reserve Bank of Peru foreign exchange intervention, we list three key theoretical channels we believe are important for Peru. First, is the coordination channel: in an uncertain environment, oral and actual interventions affect the heterogeneous expectations about exchange rate levels. In other words, interventions reduce the dispersion of expectations about exchange rates (Fratzscher 2008). This is relevant when a shock hits, and agents overreact.

A second rationale for the effectiveness of intervention is the portfolio balance channel (Kouri 1976). Given that sol-denominated and US dollar-denominated assets are perceived as imperfect substitutes, sterilized intervention (by changing the composition of agents' portfolios) affects the exchange rate.

A third factor that supports foreign exchange intervention effectiveness is the signaling channel: central banks use foreign exchange intervention to signal inside information, such as future monetary policy moves (Mussa 1981; Sarno and Taylor 2001). The crucial point here is that the central bank signals inside (previously unknown) information to the market so that it affects prices. Nowadays, we can think that the signaling has switched to inform (through interventions) about central bank assessment of fundamental factors that impinge on the exchange rate.[11]

EMPIRICAL EVIDENCE FOR INTERVENTION EFFECTIVENESS

Several papers have documented the effectiveness of Peruvian foreign exchange interventions. All papers have used high-frequency data easily available from the central bank's website, except those papers that use intraday data, such as Flores (2003), Lahura and Vega (2013), and Fuentes and others (2014). The central bank's website also publishes daily exchange rates, a feature that has also been used

[11] It should be understood that the central bank technical assessment may have superior value to that of private agents.

in Mundaca (2011) and Tashu (2014), for example.[12] All papers, but one, that have tackled the volatility issues have found that interventions have effectively reduced excess volatility.

Intervention operations seek to smooth out exchange rate volatility. This intervention is made under discretion, in real time, and considers all available information about what is happening in financial markets. A staff committee meets every day to make monetary operation decisions regarding the target interbank interest rate and to conduct foreign exchange interventions (see the following section about intervention procedures).

One important reason interventions have been effective is the amount of daily interventions relative to the size of the foreign exchange market. Were the foreign exchange market larger, the central bank would find it very difficult to have any impact on the exchange rate.

The level of financial integration and the size of the foreign exchange market may explain the effectiveness of foreign exchange intervention in reducing exchange rate volatility (Table 12.5). Figure 12.8 shows that the turnover in over-the-counter foreign exchange markets in Peru is still low even compared with countries in Latin America. In addition, Figure 12.8 shows that the size of spot foreign exchange intervention reached, at some point, up to 20 percent of the spot market turnover. Hence, the central bank is an agent with important market power in the foreign exchange market.

Another key point that aids the effectiveness of Peruvian foreign exchange intervention is the long experience (more than 25 years) of conducting operations in the spot market. Both the foreign exchange market and central bank procedures have evolved in mutual adaptation. In the process, the central bank has gained a reputation for being a strong agent, given that it has a solid balance sheet and is an informed market participant.

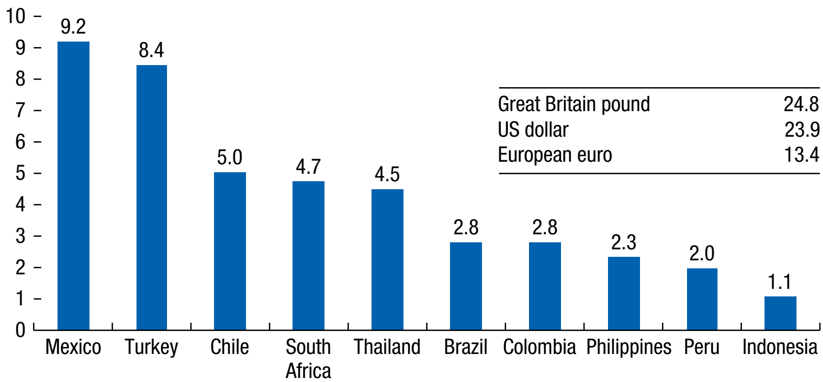
To conduct foreign exchange intervention, market information must be available—including knowing the microstructure of the market and the main flows coming from other market participants, such as nonresidents, pension funds, banks, and mining companies.

FOREIGN EXCHANGE INTERVENTION PROCEDURES

Spot foreign exchange market transactions take place primarily on a private electronic real-time trading platform operated by DATATEC. The platform is grounded on a blind system in which the bidders are known only to those involved in the transaction and become commonly known only after the transaction is closed. It operates from 9:00 a.m. to 1:30 p.m., Monday through Friday. The transactions are settled the same day under a real-time gross settlement system.

[12] The rates are published after the foreign exchange market closes.

Figure 12.8. Turnover of Over-the-Counter Foreign Exchange Instruments, 2016
(Daily averages as percentage of GDP)



Sources: Bank for International Settlements; and Triennial Survey of Foreign Exchange and over-the-Counter Derivatives Trading.

TABLE 12.5.

Selected Studies on the Effectiveness of Foreign Exchange Intervention in Peru

Authors and Year	Level	Volatility	Asymmetric	Data
Arena and Tuesta 1999	Yes	Yes		Daily: 1994–98
Flores 2003		Yes	Purchases >> sales	Intraday: January 1999 to June 2001
Shiva 2003		Yes		Daily: January 1997 to January 2004
Humala and Rodríguez 2010		Yes		Intraday: 1994–2007
Mundaca 2011	Yes	Yes		2004–2009
Lahura and Vega 2013	Yes		Sales >> purchases	Intraday: January 5, 2009 to April 27, 2011
Fuentes and others 2014	Yes	Mild		Intraday: January 5, 2009 to April 27, 2011
Rossini, Quispe, and Serrano 2014	Yes[1]			
Tashu 2014	Yes	Yes	Sales >> purchases	Intraday: January 2010 to December 2013
Durán-Vanegas 2016		Yes		Daily: 2003–15

Source: Authors' summary.
Note: Blank cells indicate "no" or an absence of analysis.
[1]Expected depreciation.

Commercial banks are the participants on the trading platform. Each bank holds a current account at the central bank, which is used to debit or credit the corresponding amount after a spot foreign exchange transaction. Per the average amount traded, only five banks concentrate most of the transactions in the foreign exchange spot market. Between January 5, 2009, and April 27, 2011, the average amount traded in the interbank spot foreign exchange market was around \$700 million a day. During the same period, the maximum amount traded in one day was about \$1.7 billion—almost 1 percent of the GDP.

MECHANISMS OF INTERVENTION

Foreign exchange intervention in Peru mainly involves direct operations with commercial banks in the spot market at the prevailing exchange rate. Also, when forward trading volume causes pressure in the foreign exchange position of banks, and thus in the spot exchange rate, the central bank intervenes through swap transactions to buy or sell US dollars or through forward-type instruments.

Interventions are sterilized to meet the prevailing interest rate target. Sterilization of foreign exchange operations employs two main instruments: central bank securities (central bank certificates of deposit), and Treasury deposits at the central bank. Of course, the latter is exogenous to the Central Reserve Bank of Peru, but the fiscal surplus during the period of the commodity boom has enabled fiscal sterilization to be the main sterilization mechanism most of the time.

As already mentioned, the Monetary and Foreign Exchange Committee decides on the amount of US dollars to be purchased or sold in the spot market, as well as the amount of swap or forward transactions to be made on any given day. It also decides the daily open market operations consistent with the monetary policy stance and the foreign exchange intervention position.

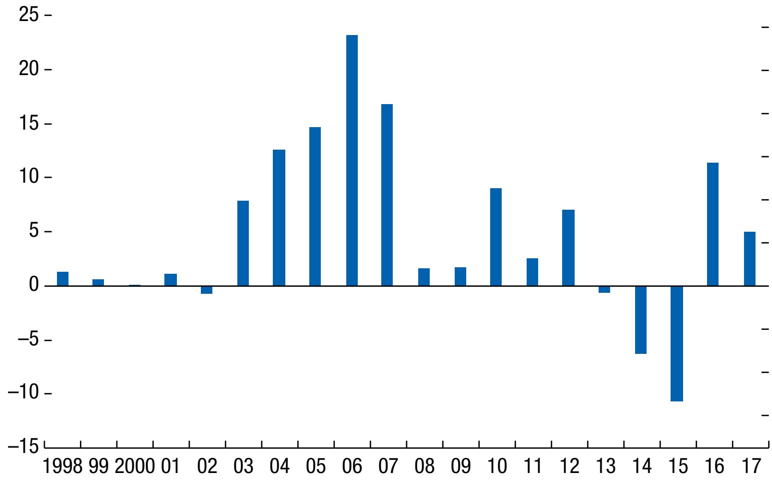
The committee decisions are made with up-to-date information of developments relevant to its operations. It is at this point that the discretion of foreign exchange intervention plays an important role.

Following the trading platform's rules, participants do not know whether the other participants (including the central bank) are buying or selling; only the Central Reserve Bank of Peru's counterparty in a foreign exchange operation can identify the central bank after the operation is closed. However, the Central Reserve Bank of Peru announces to all market participants when it starts to intervene, so that all participants become aware of it, even if they do not conduct transactions with the Central Reserve Bank.

Hence, central bank foreign exchange interventions are discretionary, in that (1) the amount to be purchased or sold is not pre-announced (Rossini, Quispe, and Rodríguez 2013) and (2) foreign exchange operations can be conducted on any day, and at any time, when the foreign exchange market is open. The amount of the intervention is published when the market closes.

The extent of intervention as a proportion of the size of the market is depicted in Figure 12.9. As can be seen, periods under stress feature sizable spot foreign

Figure 12.9. Net Yearly Purchases, Foreign Exchange Spot, 1998–2017
(Percent; ratio to yearly interbank foreign exchange turnover)



Source: Central Reserve Bank of Peru.

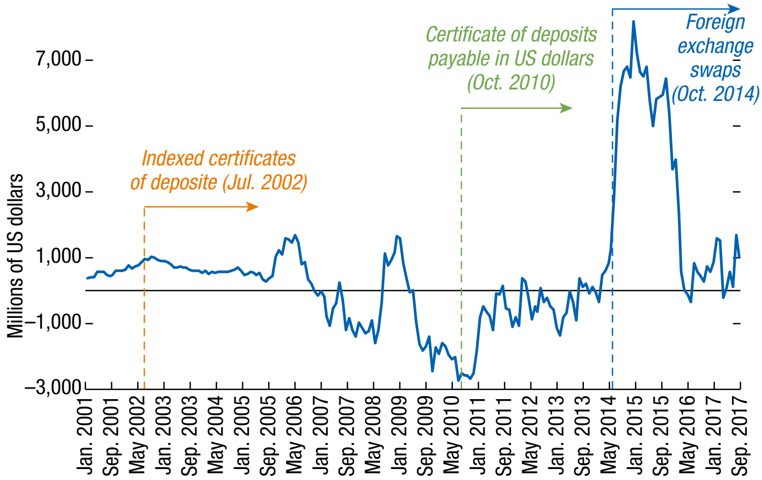
exchange intervention on the buying or selling sides. On the buying side, central bank purchases amounted to close to 25 percent in 2006, and its selling reached about 13 percent of the total spot market turnover between June 2008 and February 2009. In 2016 during another selling episode, intervention equaled 11 percent of turnover.

So far, we have described foreign exchange intervention mostly through transactions in the spot market. However, since 2002 the central bank introduced a set of indirect intervention instruments. The central bank created these instruments in response to the ever-larger size of the forward and derivative foreign exchange markets. These indirect instruments reduce pressures in the forward market, and in doing so, diminish their effect on the spot market.

Figure 12.10 shows the adoption dates of these direct instruments together with the net sale positions in the forward market. These outstanding net positions indicate if there are appreciation or depreciation pressures in the market. In July 2002, the central bank introduced indexed certificates of deposit. This instrument is like any certificate of deposit issued by a central bank; the difference is that payment in soles is indexed to the change in the exchange rate between the day of issuance and the day of maturity.

In October 2010, the central bank started using certificates of deposit payable in US dollars. The novelty of this instrument is that the purchase of the certificates of deposit at the issuing date and the payoff at maturity are made in US

Figure 12.10. Foreign Exchange Forward Net Sales Position of Commercial Banks and Adoption of Alternative Instruments, 2001–17



Source: Central Reserve Bank of Peru.

dollars. The issue of these certificates of deposit has been important whenever there has been excess dollar liquidity not easily absorbed by sterilized spot interventions. The certificates make it possible to absorb that liquidity.

In October 2014, the central bank introduced a currency swap to reduce exchange rate volatility during depreciation and appreciation episodes. Like cross-currency swaps, these are agreements between the central bank and any agent to exchange interest payments and principals on loans denominated in both soles and US dollars.

CONCLUSIONS

In the 25 years of sterilized foreign exchange intervention under the managed floating exchange rate regime in Peru, there was a gradual transition from the control of money aggregates to inflation targeting.

Since the inception of the floating regime, foreign exchange intervention has been part of a monetary policy design that took monetary stability as its paramount objective and financial stability as a necessary element.

Financial stability in a dollarized economy implies the need to avoid triggering widespread balance sheet effects that would have severe negative effects on the economy and on the transmission of monetary policy. Foreign exchange intervention, by smoothing exchange rate volatility, prevents the triggering of these balance sheet effects. This chapter shows that this lean-against-the-wind policy may be optimal for a financially dollarized economy.

Peruvian foreign exchange intervention has been effective. The chapter shows that the sol exchange rate tends to move with similar currencies but with lower variability. This result is the direct product of foreign exchange intervention. In addition, there is overwhelming empirical evidence that interventions are effective in reducing excess volatility.

Various factors point to this effectiveness. First, the scale of net international reserves relative to the size of the foreign exchange market is large and therefore allows the central bank to intervene symmetrically and decisively under appreciation or depreciation pressures. As such, being an important participant in the market in terms of scale allows foreign exchange intervention channels to affect the exchange rate.

A second factor that may explain the effectiveness of intervention has to do with intervention procedures. Interventions have always been discretionary; this means that interventions are not triggered by preannounced rules but by high-frequency assessment of market conditions and by financial and all types of developments that may affect the foreign exchange market. Therefore, the market has internalized that, given market news, the central bank is always prepared to intervene to slow exchange rate changes. This has induced a stabilizing expectational effect in the market.

A third possible factor that explains the effectiveness of intervention is the long experience of the central bank in dealing with the foreign exchange market. In more than 25 years, both the central bank and the foreign exchange market have evolved in mutual adaptation. In the process, the central bank has earned a reputation as a strong agent, given its strong balance sheet, and as an informed market participant.

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CHAPTER 13

Uruguay: Interventions and Their Effects

Elizabeth Bucacos, Alberto Graña, Gerardo Licandro, and Miguel Mello

In the wake of the global financial crisis in 2008, the Central Bank of Uruguay faced challenges in global capital flow volatility. It used different tools within the framework of its inflation-targeting regime to cope with the volatility and foreign exchange misalignments. This chapter, in its study of the effects of foreign exchange intervention in Uruguay during 2005–17, analyzes whether responses in the Uruguayan peso/US dollar rate vary with different types of intervention. Relying on a monthly vector autoregressive and a two-step approach using weekly data, the analysis finds robust evidence for a significant but short-term effect of intervention on the nominal exchange rate, depending on the type of intervention. Response seems to be asymmetric depending on whether the intervention involves net purchases or net sales. The evolution of macroeconomic and financial indicators suggests that the combination of foreign exchange intervention with other monetary and macroprudential measures succeeded in Uruguay, so that significant real exchange rate misalignments could be avoided, thus impeding the effects of large capital flow swings and domestic portfolio changes on economic activity and macroeconomic stability.

INTRODUCTION

As a small, open economy with free capital movements, a floating exchange rate, and high currency substitution within the framework of an inflation-targeting regime, Uruguay has faced significant challenges during the financial turmoil of recent years. This chapter covers the phases of the economic cycle in the country and the international macro financial cycle during 2005–17.

The global financial crisis that began in the United States in 2008 caused large capital inflows into emerging market economies. Besides "traditional" monetary

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easing, a series of unconventional policy measures—including long-term asset purchases by the US Federal Reserve, the European Central Bank, the Bank of Japan, and the Bank of England—led to reallocation of funds from advanced economies to the emerging markets (see Kolasa and Wesolowski 2018). This put appreciation pressures on their exchange rates. The macro-financial cycle during that period also exhibited high financial market volatility, capital flow reversals linked to greater uncertainty and risk aversion, and changing expectations of rates of return of currencies and assets. In short, these global and regional shocks posed risks to macroeconomic stability. The sudden and large portfolio changes by domestic and external institution investor markets posed risks of misalignment and macroprudential issues.

In general, the response to such global shocks in financially open economies involves the use of monetary, fiscal, financial, and macroprudential tools. The specific findings of this chapter's scrutiny of policy responses show that foreign exchange intervention was an effective tool (if not the only one) for dealing with the adverse global capital flow shocks on emerging market economies (for example, see Blanchard, Adler, and de Carvalho Filho 2015; Daude and others 2016).

In Uruguay's policy response, the countercyclical role of sterilized foreign exchange intervention was complemented by an asset and liability approach to the integrated balance sheet of the public sector and reserve requirements on nonresident investments in public debt in the primary market (Vicente, Malacrida, and Zimet 2017). Taken together, these monetary and financial tools helped temper the adverse effects of large capital flow swings and the related domestic portfolio changes on foreign exchange fundamentals. It also helped control volatility in relative prices, currency markets, and interest rates.

Foreign exchange intervention was a Uruguayan trademark in the fifteen years after the currency was allowed to float, in response to the 2002 crisis.[1] Indeed, Uruguay is among the most active Latin American countries in this regard, and in a region where intervention through varying mechanisms was widespread in the period reviewed.

As such, Uruguay is relevant to the discussion for its significant levels of intervention under its inflation-targeting regime that use monetary aggregates as the instrument, and because it is one of the most highly dollarized countries in the region.

This chapter aims to answer a series of questions. Do interventions affect the level or the volatility of the exchange rate? Are direct interventions (foreign

[1] In 2002, Uruguay experienced triple crises: balance of payments, banking, and fiscal. An initial exogenous contagion from Argentina to the Uruguayan financial sector magnified the inherent weaknesses of the Uruguayan economy and its banking sector. Increasing withdrawals diminished the level of available international reserves, which were eventually insufficient to both service the external debt and continue backing the large proportion of foreign currency–denominated deposits still present within the system. Finally, the Uruguayan authorities had to let the peso freely float– which immediately depreciated by 27 percent—and declared a five-day bank holiday on July 30, 2002. See Bucacos (2017) for a detailed description.

exchange purchases/sales in the spot market) different from indirect interventions (export prefinancing and so on)? Do sterilized interventions have an effect?

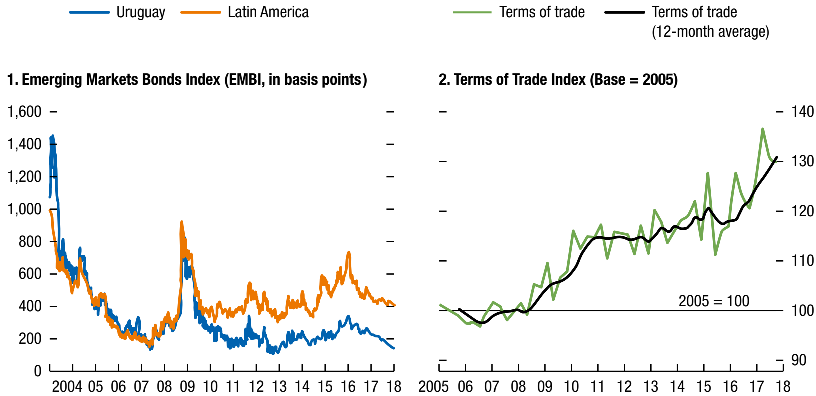
Because the chapter focuses on the impact of different types of intervention rather than on effectiveness itself, it concentrates on implementing a well-understood and accepted methodology. To do this, it examines whether one can identify the different exchange-rate responses to the different types of intervention, and it uses two approaches: With monthly data, it estimates a simple vector autoregressive (VAR) in differences between the variables generally used in empirical models of the exchange rate and exchange rate intervention. With monthly and weekly data (not reported here), it applies to Uruguay the two-stage approach proposed by Adler and Tovar (2014).

The results suggest the following:

- Interventions affect the level of the exchange rate, but the effect is short-lived;
- Although the effect of indirect interventions appears with the expected sign, and is statistically significant, direct interventions get a meaningful response through foreign exchange sales, while purchases "just" prevented the peso from appreciating further;
- Sterilized intervention does not seem to affect the level of foreign exchange for more than one week after foreign exchange purchases, explaining why no effect is found when monthly data is used;
- Interventions have asymmetric effects on the foreign exchange rate; that is, purchases of foreign exchange (which tend to increase the UY peso/US dollar rate) are more costly in terms of GDP than are sales of foreign exchange (which tend to decrease its cost);
- Communication to the public of relevant information regarding the value of the exchange rate seems to play a role in the motives of de facto intervention;
- The central bank seems to worry about the level of the appreciation velocity of the foreign exchange, rather than its volatility;
- Real exchange rate misalignments seem to have been a reason for intervening only in the case of central bank sales; and
- The flip side of sterilized interventions is the increase in the stock of monetary regulation securities, and these excess reserves are a macroprudential buffer with associated costs, because of interest rate differentials between Uruguay and the United States.

The combination of different tools, including foreign exchange intervention, helped avoid foreign exchange misalignments and levels of volatility incompatible with macroeconomic stability. The next section describes the characteristics most relevant to analyzing intervention in Uruguay in the stated period. The chapter describes the VAR methodology and its results, and the results of the two-stage approach.

Figure 13.1. International Indicators for the Uruguayan Economy, 2004–18



Sources: Bloomberg Finance L.P.; and Economic Commission for Latin America and the Caribbean.

Uruguayan Intervention and Monetary Policy during 2004–17

Several important characteristics are needed to understand monetary policy and foreign exchange interventions in Uruguay in the period examined, including a short description of the macroeconomic environment, relevant structural facts, and the institutional setup of monetary policy.

The Macroeconomy during 2004–17

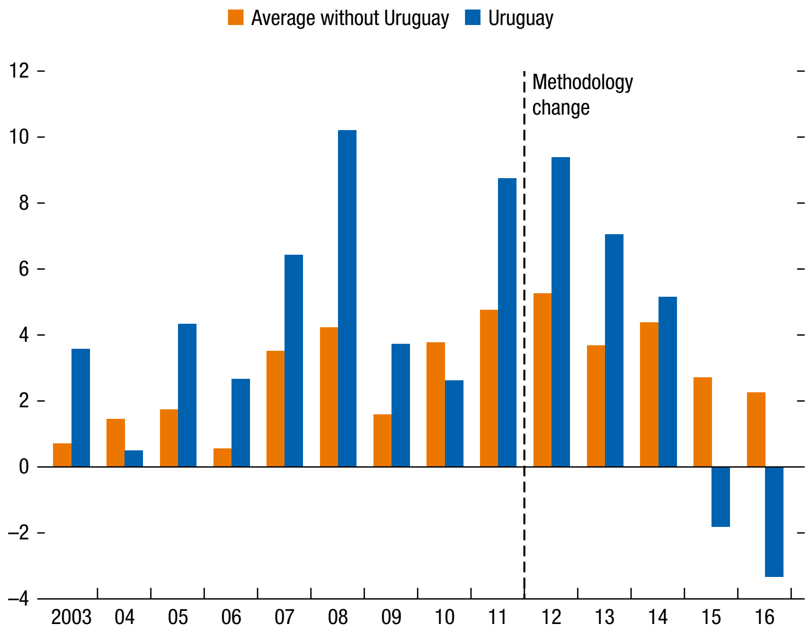
Figure 13.1 describes the relevant international environment. Financial conditions had been exceptionally good, though extremely volatile, since the global financial crisis began in 2008, sparking a globally coordinated and expansive monetary policy stance. This resulted in low interest rates and country risk premiums, but these were under a permanent threat of reversion. Commodity prices and terms of trade were high though volatile. Regional demand was also a positive factor through most of the period. Both Argentina and Brazil had internal political problems, but regional output was generally positive. Uruguay's economy entered a prolonged expansion cycle between 2004 and 2017, albeit with slower growth during 2009 and 2013–17.

These generally favorable results emerged, as noted, despite episodes of high volatility in financial markets, capital flow reversals linked to greater uncertainty and higher risk aversion, and changing expectations on rates of return for currencies and assets during the period.

Structural Facts to Understand Intervention in Uruguay

The US dollar is important to Uruguay's financial and price systems, and the country remains highly dollarized, even though currency mismatches have

Figure 13.2. Balance of Financial Account: Regional Comparison, 2003–16
(Percent of GDP)



Sources: Central Bank of Uruguay; and IMF calculations.
Note: Balance of financial account is depicted in percent of GDP, for a given year. The orange bar represents the simple mean of that ratio for Brazil, Chile, Colombia, Paraguay, and Peru.

recently declined. Deposit dollarization, although down recently, remains close to 80 percent of total deposits. The currency composition of banking credit, however, has changed, with dollarization falling below 50 percent in 2017.

Firms' financial positions have been transformed since the 2002 crisis, greatly reducing exchange rate exposure on balance sheets, although dollar leverage remains high. At the same time, the government has increased the share of domestic debt and accumulated a large portfolio of international reserve assets. Domestic financial markets remain very shallow, including foreign exchange markets. Domestic markets grew during 2004–17, but their size remains very small by global standards. The wholesale exchange rate market amounts to only 12 percent of GDP and is strongly concentrated on the purchasing side. The stock of exchange rate forwards in Uruguay, meanwhile, amounts only to a little over 3 percent of GDP, and turnover is very small.

The financial system is, likewise, very concentrated, dominated by public banks and pension funds. Only 11 banks are operating, and public banks hold 49 percent of total liabilities, while the four pension funds in the country control a combined asset portfolio (mostly in government bonds) that amounts to 23 percent of GDP.

The US dollar also plays a big role in the price system, as noted. Tradable goods account for close to 40 percent of the consumer price index (CPI) basket, which leads to a high speed of exchange rate pass-through.[2] Meanwhile, US dollar invoicing of domestic sales is widely extended in the wholesale sector (an internationally unusual practice), as Baron and others (2017) show.

One final important fact is that the government needs to purchase large amounts of foreign exchange to cover its operational flows (Figure 13.2). Because Uruguay is an oil-importing country, and energy-producing utilities are state owned, the government has traditionally needed to purchase foreign currency to pay for those imports. Oil imports amounted to 4 percent of GDP in this period (2004-17), representing 40 percent of energy demand. The change in the net foreign position of the Uruguayan government has reduced the traditional need to purchase currency to service debt.

Intervention Characteristics

This section details features of intervention in the Uruguayan foreign exchange market, mainly regarding agents and types of intervention.

Intervention Goals

As can be seen, the US dollar looms large for prices and financial stability. As the weight of tradable goods in the CPI basket is high, and several nontradables are invoiced in US dollars, the pass-through of the exchange rate to inflation is fast. In addition, because most financial transactions are in US dollars, domestic balance sheets are exposed—despite the recent reduction in currency mismatches—to wealth effects that might affect the asset side more strongly because of quality mismatches between assets and liabilities. These factors justify the strong informational value of the US dollar in the Uruguayan society and the government, and are reasons behind the close watch that the government keeps on exchange rate behavior.

Central bank authorities therefore explain intervention in the foreign exchange market as responding to real exchange rate misalignments and *excessive* volatility relative to sustainable fundamentals in the market. In particular, the central bank explains its resistance to validating *transitory* shocks to the appreciation of the domestic currency as concerns over real activity and long-term decisions of the private sector. For example, amid strong capital inflows, in July 2012, Mario Bergara, president of the Central Bank of Uruguay at the time, stated that authorities should be able to differentiate permanent versus transitory shocks: "Zero percent interest rates are not going to last long," and determine intervention with an aim to reduce the impact of the shock on the real sector.[3] On the other hand, authorities have tried to avoid discrete jumps in the exchange rate on financial

[2] Licandro and Mello (2018) show that the high degree of cultural dollarization in Uruguay is, in part, due to the dollarization of the price system, particularly housing prices.

[3] Mario Bergara in the Official Spanish Trade, Industry and Sailing Chamber. Published in Busqueda, #1670, July 12–18, 2012.

stability grounds. In September 2015, Bergara claimed that "the Uruguayan (s)ociety is still afraid of what could happen if the exchange rate leaps: that's why we cannot allow the exchange rate to be a rollercoaster".[4]

Intervention as a Rule, Not an Exception

Intervention, by Type

Uruguayan authorities use several types of intervention mechanisms in the foreign exchange market. The analysis here concentrates on two classifications:

- Sterilized and nonsterilized interventions, and
- Direct and indirect interventions

As Uruguay manages monetary aggregates, defining sterilized interventions becomes more problematic than when a monetary authority controls the interest rate. When a central bank controls interest rates, the researcher can assume that interventions are sterilized, as long as the interest rate in the money market remains unaffected, as the monetary effect of the intervention should be zero. When a monetary authority controls monetary aggregates, an intervention is sterilized if the monetary program remains on track, meaning that the expansion generated by the unexpected purchase of foreign currency is compensated by open market operations. Regular purchases of currency by the central bank might not be a good proxy in a dollarized economy, as the central bank might resort to purchasing/selling foreign exchange to sterilize/issue liquidity as part of its regular monetary operations. Since the correct proxy for sterilization is not available, this analysis uses the net of foreign reserves and debt issued by the central bank as the indicator of sterilized intervention.[5]

Figure 13.3 shows that sterilized and nonsterilized interventions are carried out simultaneously, in some months as substitutes and in other months as complements. The interaction of different instruments to intervene in the exchange market accumulated international reserves in the central bank, which significantly increased the stock of monetary regulation securities along with its maintenance cost (see Figure 13.4).

Figure 13.5 presents the estimated cost of the surplus reserves, calculated as follows:

$$CSR_t = \frac{\left(R_t - SR_t\right)\left(i_t^{Uy} - i_t^{USA}\right)}{Y_t}, \tag{13.1}$$

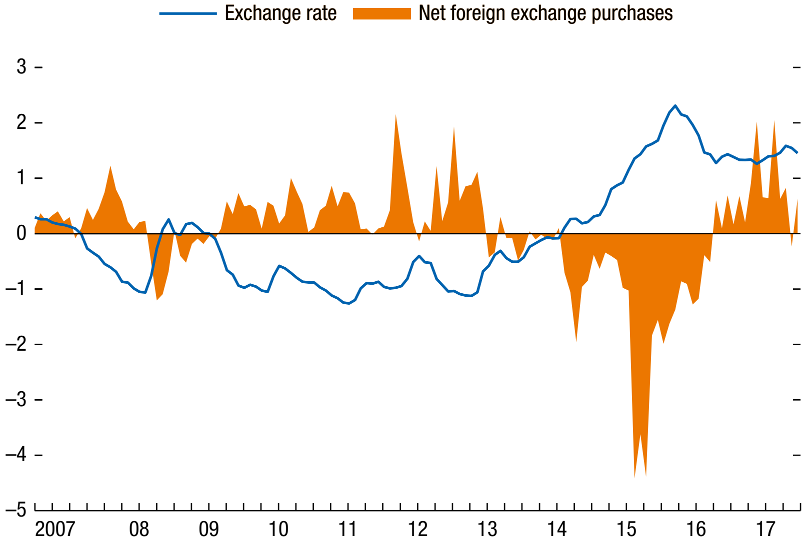
where R_t is the annual average reserves expressed in millions of US dollars; SR_t is the annual average "comfortable" level of reserves;[6] $\left(i_t^{Uy} - i_t^{USA}\right)$ is the annual

[4] Busqueda #1835, October 1–7, 2015.

[5] Uruguay uses its own debt in open market operations.

[6] Uruguay has a safety criterion for reserve adequacy. It consists of ensuring the level of reserves that would allow the central bank to fulfill all mandates set by the law in 99 percent of cases. The basic criterion is set forth in Ibarra and others (2011).

Figure 13.3. Foreign Exchange Net Purchases and Exchange Rate, 2007–17
(Normalized data)



Source: Authors' calculations based on Banco Central del Uruguay's data.
Note: Normalization implies subtracting the mean of the variable and dividing it by its standard deviation. The large sales from August to October 2015 correspond to a repurchase of central bank notes of $655 million and an exchange of central government notes with the central bank of $831 million.

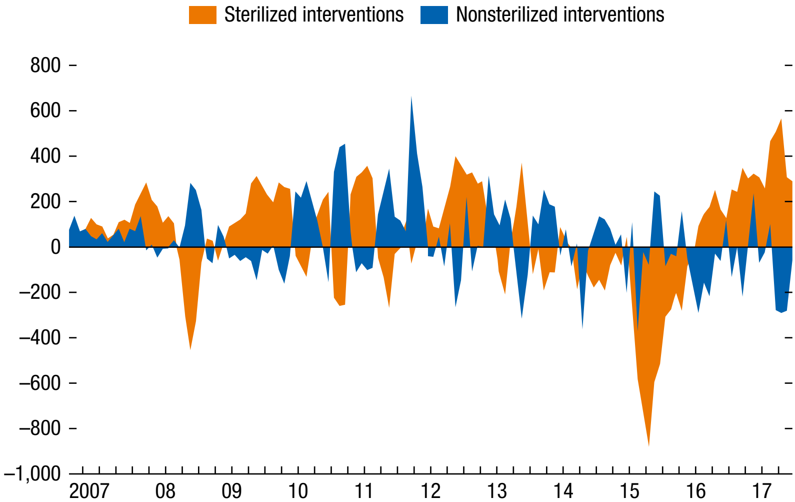
average spread between Uruguayan and US bonds, and Y_t is current Uruguayan GDP expressed in millions of US dollars.

Interventions can be either direct or indirect. Indirect interventions refer to several operations: (1) Settling local currency securities in US dollars (this avoids an effect on the foreign exchange market of foreign exchange conducted in the purchase/sale of public paper), (2) exchange forwards settlements, and (3) export prefinancing. Direct interventions refer to sales or purchases in the exchange market, both spot and forward. The main reason for the distinction is the communication role of interventions. Other agents observe direct intervention and internalize information for financial decisions; while indirect interventions are not visible to the market in real time.[7, 8] As Figure 13.4 shows, indirect interventions are much bigger by volume than direct interventions, though the mean monthly interventions are similar (see Annex 13.1).

[7] Information on indirect intervention operations is available at the close of day.

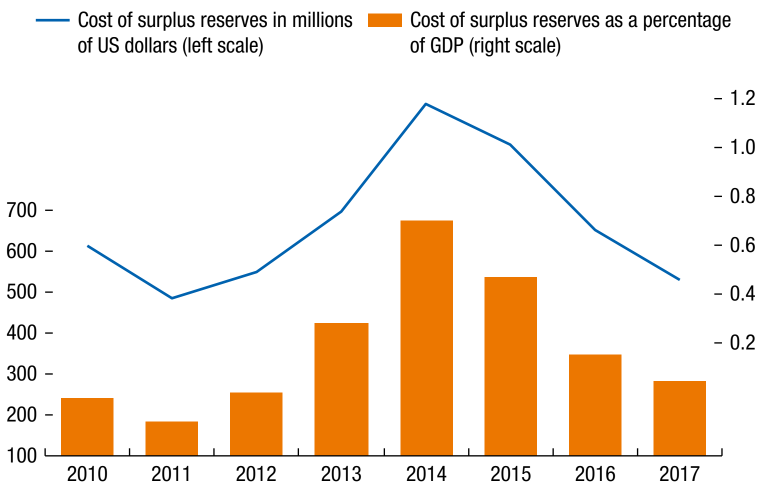
[8] Because of the size and intensity of central bank intervention, financial agents can easily identify when the central bank is intervening.

Figure 13.4. Sterilized and Nonsterilized Interventions, 2007–17
(Millions of dollars)



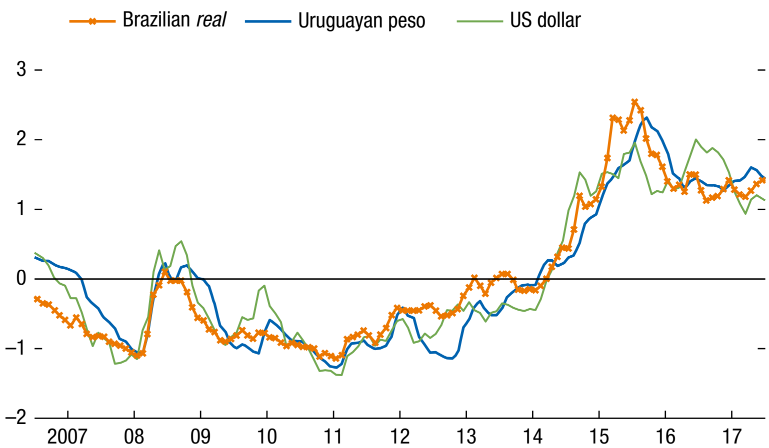
Source: Authors' calculations, based on Banco Central del Uruguay's data.

Figure 13.5. Estimated Cost of Surplus Reserves, 2010–17



Source: Authors' calculations, based on Banco Central del Uruguay's data.

Figure 13.6. Brazilian *Real*, Uruguayan Peso, and US Dollar Comovements, 2007–17



Source: Authors' calculations based on Banco Central del Uruguay's and Federal Reserve's (FRED) data.
Note: Nominal exchange rates (UY peso/foreign currency) are normalized. That process implies subtracting the sample mean and dividing by the standard deviation.

Monetary Policy Design and Implementation

For background on monetary policy conduct in Uruguay during 2004–17, the analysis details the institutional setup of monetary policy and its history.

Institutional Setup of Monetary Policy

The Central Bank of Uruguay carries out monetary policy with a dual mandate from its charter law's statement of main goals: "price stability that is consistent with growth and employment" and financial stability. The charter also describes how the central bank interacts with the Ministry of Finance: there is a Macroeconomic Coordination Committee to generate an environment of coordination between the central bank and the executive. If a disagreement arises about the "monetary policy system," the opinion of the Ministry of Finance prevails.[9] Practice shows that this committee meets quarterly, just before the meeting of the Monetary Policy Committee. The committee, internal to the central bank, is in charge of deciding monetary policy and is comprised of the members of the board of the bank (the only ones with voting power), the heads of the Monetary Policy and Markets and Economic Advising divisions, and other top officers of the central bank invited in an advisory function. Monetary policy is conducted through central bank bills and other forms of liquidity injection/sterilization, including foreign exchange operations.

[9] There is no record that this mechanism was used in the period.

Meanwhile, the Debt Committee coordinates placement of central bank and government paper in the market. Traditionally, central bank paper is issued in short maturities and government paper with maturities over two years.[10] In Uruguay, the countercyclical role of sterilized foreign exchange intervention is complemented by the use of an asset and liability approach to the integrated balance sheet of the public sector and reserve requirements on nonresident investments in public debt in the primary market.[11]

Stages of Monetary Policy since 2002

Uruguay moved to a floating exchange rate system after the July 2002 collapse of the exchange rate crawling band. The period from 2002 to the present can be divided into four stages according to the monetary system implemented:

1. As the country was exiting the turmoil of the crisis, it transitioned toward inflation targeting, a period that lasted until the end of the first semester of 2004.
2. Between the second semester of 2004 and the first of 2007, Uruguay had what can be called an inflation-targeting system managing monetary aggregates as the instrument of monetary policy.
3. From the second semester of 2007 to the first semester of 2013, the country operated an inflation-targeting regime with the one-day nominal rate as the instrument of monetary policy.
4. From the second semester of 2013, the country returned to the management of its inflation-targeting regime with monetary aggregates.

The first (transition) phase was a reorganization phase. Uruguay would not solve fiscal sustainability until the May 2003 debt restructuring was completed. In that phase, the central bank tried to show the public that it could deliver on monetary policy by setting targets for the monetary base, with no reference to an inflation target. In that period, the commitment to inflation was gradually increased, while the commitment to the monetary target (first the base but later M1)[12] was phased out. Inflation as a reference was introduced for 2003. Then, the language of the central bank would start to give greater relevance to inflation, to finally call it an inflation target by the end of the first semester of 2004. Initially, the central bank announced a target for the monetary base of the following year. Later, that reference was transformed into a target for M1 and by the second semester of 2004 there was a reference for M1 in a target that implied no commitment. One of the priorities of the transition was restoring international reserve

[10] The Macroeconomic Coordination Committee was created by the 2007 Charter Law of the Central Bank.

[11] See Malacrida, Vicente, and Zimet (2017).

[12] M1 is the sum of money in the hands of the public plus domestic-currency transactional deposits of the private sector in the banking system.

assets to a comfortable level. This was accomplished by late 2003 according to the safety criteria of the central bank.[13]

In the second semester of 2004, during the second phase, even though the central bank would not officially recognize it, Uruguay was in an inflation-targeting regime. That is, the central bank had a public target for inflation and no commitment whatsoever to monetary aggregates.

The first phase of inflation targeting with monetary aggregates was marked by consistent surprises in money demand growth. Money demand until 2002, because of the incentives that led to the dollarization of the Uruguayan economy (see Licandro and Licandro 2003), trended downward. After the debt restructuring, and the implementation of several regulatory changes to deal with the financial stability threat that posed currency mismatches, the trend of money demand changed, and Uruguay started to experience a period of strong remonetization. The favorable environment described in the previous section was also a factor. As a result, monetary policy was consistently more contractive than forecasted, leading to the piercing of the lower bound of the inflation target in the first semester of 2005, and to increasing public pressure on monetary policy because of the strong appreciation of the currency.

Against this background, the central bank decided to change the instrument of monetary policy to the one-day interest rate in the second semester of 2007 (the third phase). International volatility marked the period. On the negative side, both the Lehman Brothers and the European debt crises occurred. On the positive side, Uruguay regained investment grade status by all rating agencies, and it experienced positive financial market access shocks that enhanced the volatility of capital inflows. Furthermore, Uruguay experienced strong foreign direct investment associated with high commodity prices, the development of pulp paper production, and increasing restrictions on agricultural production in Argentina.

During the Lehman Brothers episode, the Latin American region, mostly with inflation and inflation expectations under control, decided to provide liquidity and lower interest rates; however, Uruguay took a completely different approach. Concern over the effects on financial stability of a jump in the exchange rate only six years after the Uruguayan crisis of 2002, led the central bank to exercise an interest rate defense of the exchange rate. As the liquidity shortage in foreign currency grew, the Uruguayan government decided to assist the portfolio change by offering a repurchase of short-term domestic paper, but in limited amounts. As a result, the interest rate jumped. Once the worst of the international liquidity crunch passed, Uruguay allowed the interest rate to return to 10 percent, a level chosen to control inflation and inflation expectations.

Despite the environment that followed the Lehman Brothers episode, both inflation and inflation expectations remained outside the target set by the Macroeconomic Coordination Committee. In May 2013, two days before the announcement of tapering by the US Federal Reserve, Uruguay announced a

[13] See Licandro (1999) and Della Mea and others (2011).

return to the management of monetary aggregates. The announcement was made amid concerns about the cost of sterilization and high portfolio capital inflows after Uruguay's credit rating was raised to investment grade by a second agency, effectively opening it up to institutional investor capital.

The next section explores the effectiveness of government actions on the exchange rate, identifying whether different types of intervention (sterilized or nonsterilized, direct or indirect) had different impacts on the exchange rate.

VAR METHODOLOGY

The data set for the empirical analysis was obtained from three sources: the Electronic Stock Exchange, the Central Bank of Uruguay, and Bloomberg Finance L.P. It uses monthly data from January 2007 to December 2016 for exchange rates, net foreign exchange purchases of governmental institutions, domestic and foreign interest rates, and risk and volatility measures, such as the VIX index and the Emerging Market Bond Index (EMBI).

The analysis uses a multivariate time series approach to measure the impact of interventions over the parity Uruguayan peso–US dollar (Annex 13.1 presents the main descriptive statistics for the variables used). During the period, the central bank participated heavily in the exchange market, mainly through open market operations sterilizing capital inflows. There is no significant size difference between direct and indirect interventions. Included in the analysis are other variables that are standard in the literature: the exchange rate in Brazil, Uruguayan interest rates, expected inflation and expected depreciation, the VIX Index, and the EMBI for emerging markets.[14, 15]

Figure 13.6 shows the very close relationship between the Uruguayan peso and the international US dollar value, which leads to thoughts about possible cointegration. That assumption is backed by a Johansen test for cointegration. As net foreign exchange purchases (NFXP) is $I(0)$ and endogenous, we decided to estimate a VAR model in differences for the exchange rates series, treating interventions as an endogenous variable.

The VAR model, expressed in matrix form, is represented as follows:

$$Y = BZ + CX + U, \tag{13.2}$$

where Y denotes the endogenous variables vector, Z is the autoregressive matrix of the endogenous variables, and X represents the matrix of the exogenous variables.

The endogenous variables are: ΔE_t^{Brl} Brazilian *real*, in differences; ΔE_t^{Uy} domestic exchange rate, in differences; $NFXP_t$ net foreign exchange purchases, in

[14] It presents the 1-month rate for the Uruguayan peso-nominated yield curve, the 1-year US dollar-nominated yield curve, and the 1-year node for indexed unit yield curve. The indexed unit is an accounting unit that indexes the Uruguayan peso by inflation.

[15] The analysis does not use EMBI Uruguay, to avoid collinearity with interest rates.

levels; I_COMM_t communications, a discrete variable, nominal interest rate, in levels; r_t^{UI} indexed unit interest rate, as a proxy of real interest rate, in levels; d_{t+1}^e expected depreciation, in levels.[16] The exogenous variables are: i_t^{US} nominal interest rate for the United States, in levels; ρ_t^{EME} emerging markets EMBI; VIX_t VIX index, in levels, as a measure of volatility.

Estimation Results

The analysis estimates a general model for all interventions, a model separating direct and indirect interventions in the exchange market, a model distinguishing sterilized and nonsterilized interventions, and a model differentiating the central bank's and central government's interventions (see Table 13.1). It also analyzes the response of the exchange rate and the expected depreciation to a change of one standard deviation in net foreign exchange purchases for different types of intervention. It uses Choleski factorization for identification, which is particularly controversial, since the arbitrary order assigned to the endogenous variables could determine the impulse response functions. The order assigned was:

$$\Delta E_t^{Brl} \rightarrow \Delta E_t^{Uy} \rightarrow NFXP_t \rightarrow I\_COMM_t \rightarrow d_{t+1}^e \rightarrow i_t \rightarrow r_t^{UI} \qquad (13.3)$$

The logic in assigning this order is that the domestic market observes the exchange rate of its relevant market from a financial economic perspective (Brazil) whose movements are transmitted to the domestic exchange rate, the central bank in the foreign exchange market, said intervention is collected by the agents through the expected depreciation, which, via Fisher's open parity, affects domestic interest rates.

All Foreign Exchange Interventions

As can be seen in Table 13.1, the effect of interventions on the exchange rate level is barely significant and lasts only a short time. The response of the change in the exchange rate to an increase of one standard deviation in the interventions in the exchange market is significant and positive, with a very short duration, one period ahead, as presented in Figure 13.1.1. The expected depreciation (one-year horizon) is negative and significant for the second and third period ahead. This result is consistent with the perception among market players that the effect of intervention is transitory. In a scenario of appreciation of the peso, intervention briefly sustains the domestic price of the US dollar, but after the effect of intervention is over, expected depreciation anticipates an appreciation of the peso**.**

Evidence suggests that communications are effective in the short term. When the government communicates the concerns behind monetary policy actions and foreign exchange intervention, this communication moves the exchange rate in the desired direction (Table 13.1).

[16] The communications variable takes the value of 1 if the government signals concern over appreciation of the currency, –1 when it expresses concern over the depreciation of the currency, and 0 otherwise. It is constructed using public statements after monetary policy meetings.

TABLE 13.1.

Models Estimated, Monthly Data

	VAR Global Interventions		VAR Direct and Indirect Interventions			VAR Sterilized and Nonsterilized Interventions		
	ΔE^{Uy}_t	$NFXP_t$	ΔE^{Uy}_t	$NFXP\_DIR_t$	$NFXP\_IND_t$	ΔE^{Uy}_t	$NFXP\_STER_t$	$NFXP\_NONSTER_t$
ΔE^{Brl}_{t-1}	1.290***	33.460***	1.323***	196.317	–47.375	1.291***	0.868	–0.945
	(0.500)	(73.288)	(0.610)	(191.648)	(116.816)	(0.518)	(0.676)	(1.258)
ΔE^{Uy}_{t-1}	1.195***	–29.658***	1.098***	–33.980	–59.206***	1.116***	–0.423***	0.282
	–0.0896	(13.138)	(0.140)	(44.132)	(26.900)	(0.100)	(0.128)	–0.239
ΔE^{Uy}_{t-2}	–0.404***	21.156*	–0.344***	30.756	27.524	–0.342***	0.458***	–0.410*
	(0.084)	(12.251)	(0.118)	(37.221)	(22.688)	(0.091)	(0.118)	(0.220)
$NFXP_{t-1}$	0.001*	0.296***						
	(0.000)	(0.089)						
$NFXP_{t-2}$	–0.001	0.201***						
	(0.001)	(0.085)						
$NFXP\_IND_{t-1}$			0.129*	–0.296*	0.265***			
			(0.073)	(0.161)	(0.097)			
$NFXP\_EST_{t-1}$						0.001	0.672***	–0.513***
						(0.090)	(0.118)	(0.220)
$NFXP\_NONSTER_{t-1}$						0.104***	0.096	0.152
							(0.062)	(0.115)
$NFXP\_NONSTER_{t-2}$						0.040	0.137***	–0.057
						(0.048)	(0.062)	(0.116)
$I\text{-}COMM_{t-1}$	0.238***	0.918	0.561***	–6.895	–22.424			
	(0.112)	(16.362)	(0.161)	(50.625)	(30.858)			
i^{Uy}_{t-1}	0.014	11.070***	–0.053	3.174	35.177***			
	(0.036)		(0.057)	(18.000)	(10.972)			
d^{e}_{t-1}	0.264*	–27.749				0.246*	–0.416***	–0.838***
	(0.148)	(21.654)				(0.149)	(0.180)	(0.362)
γ^{UI}_{t}	0.142***	6.936	0.011	–11.837	–62.454***	0.133**	0.175*	–0.531***
	(0.065)	(9.591)	(0.152)	(47.781)	(29.124)	(0.067)	(0.109)	(0.202)

(continued)

TABLE 13.1. ***(continued)***

Models Estimated, Monthly Data								
	VAR Global Interventions		**VAR Direct and Indirect Interventions**			**VAR Sterilized and Nonsterilized Interventions**		
	ΔE^{Uy}_t	$NFXP_t$	ΔE^{Uy}_t	$NFXP\_DIR_t$	$NFXP\_IND_t$	ΔE^{Uy}_t	$NFXP\_STER_t$	$NFXP\_NONSTER_t$
ρ^{EME}_t	0.285***	−25.693**	0.437***	−123.026***	−64.724**	0.278***	−0.004	−0.318
	(0.090)	(13.200)	(0.174)	(54.542)	(33.245)	−0.092	−0.119	−0.222
i^{USA}_t	0.398***	−38.656***	−0.145	15.563	−96.255*	0.417***	−0.149	−0.342
	(0.100)	(14.670)	(0.290)	(90.981)	(55.456)	(0.101)	(0.132)	(0.246)
VIX_t	0.016**	−0.986				0.015**	−0.023***	0.0207
	(0.001)	(1.144)				(0.008)	(0.010)	(0.019)
D_1	0.124928	−265.301***	0.680	26.034	−388.197***	0.063	−1.214***	−2.504***
	(0.275)	(40.379)	(0.455)	(142.987)	(87.155)	(0.447)	(0.583)	(1.084)
C	−1.092***	161.715***				−1.008***	0.350	1.253*
	(0.330)	(48.433)				(0.342)	(0.446)	(0.830)
R^2	0.945	0.797	0.955	0.577	0.850	0.947	0.846	0.464
Adjusted R^2	0.935	0.759	0.937	0.399	0.783	0.935	0.810	0.341
No. of observations	131	131	82	82	82	131	132	133

Source: Authors' calculations.

Note: Not available are data that discriminates between direct and indirect interventions before March 2011. VAR = vector autoregression.

$^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Direct and Indirect Foreign Exchange Interventions

Direct interventions refer to operations done directly in the exchange market. Contrary to expectations of the analysis, indirect interventions have a stronger effect on exchange rate changes than direct interventions do. The effect on the expected depreciation is similar to the previous model for general intervention. Direct interventions do not seem to explain changes in the foreign exchange rate in a statistically meaningful way. Indirect interventions are barely significant in the short term. Figure 13.2.1 presents the impulse response functions of these VAR models. Interventions seems to be incorporated by the agents in their expectations: When the effect of a purchase of foreign exchange over the exchange rate fades, expectations of domestic currency appreciation begin to appear. As Table 13.1 shows, indirect interventions are negatively correlated with direct interventions, so they seem to be used as substitutes in some periods.

Sterilized and Nonsterilized Interventions

Table 13.1 also shows that sterilized interventions do not affect the exchange rate. Nonsterilized interventions are effective in impacting the exchange rate level for a short period. When the effect of the nonsterilized interventions over the exchange rate end in the medium term, expectations of local currency appreciation appears. It seems that sterilized and nonsterilized interventions are used simultaneously in a complementary form, and are thus positively correlated.

Overall, the evidence in this section points to a short-lived effect of nonsterilized intervention. Effects of sterilized intervention using this VAR methodology could not be found. Communications do seem to play a role in the short term, as expected by the literature.

The next section delves deeper into the analysis of weekly data using the approach suggested by Adler and Tovar (2014).

TWO-STAGE APPROACH

This section describes the two-stage approach to weekly data and presents the estimation results. It analyzes the problem in more detail by expanding the frequency data, and in that way, it is expected to improve the understanding of the effectiveness and duration of foreign exchange intervention.

Econometric Approach

It is quite difficult to discern the direction of causality between foreign exchange intervention and foreign exchange performance, as intervention affects the exchange rate, and the decision to intervene depends on the evolution of the exchange rate. In effect, simple correlation between them would wrongly suggest that an increase in foreign exchange purchases would appreciate the exchange rate (measured as domestic currency per foreign currency). To overcome this endogeneity problem, as is well-known in the foreign exchange intervention literature

(Kearns and Rigobon 2005), this analysis follows the two-stage estimation process in Adler and Tovar (2014). In the first stage, a de facto reaction function for the central bank is estimated; in the second stage, predicted values of this reaction function are used as instruments in the estimation of a behavioral equation for the exchange rate.[17]

First Stage: Central Bank Reaction Function

The central bank reaction function is modeled as a censored variable and estimated with a Tobit model, with weekly data during January 2005–December 2017.[18,19] Formally:

$$I_t = max\left(0,\ \beta_0 + \beta_1 De_{t-1} + \beta_2\left(reer_t - reer_t^{eq}\right) + \beta_3 \Delta_t + \beta_4 \sigma_t + \beta_5 R_t^{M2} + \beta_6 C_t + u_t\right), \tag{13.4}$$

where I_t is the amount of interventions (net purchases or net sales as percentage of GDP) in different versions: sterilized versus nonsterilized, direct versus indirect; De_{t-1} is the lagged change in the bilateral exchange rate (Uruguayan peso/US dollar) that captures short-run movements; $reer_t - reer_t^{eq}$ stands for real effective exchange rate misalignments; Δ_t is a measure of the nominal appreciation/depreciation velocity (over trend (HP)); σ_t is a nominal exchange rate volatility measure (over trend (HP)); R_t^{M2} is a reserve assets over M2 ratio, which captures precautionary motives; *Ct* reflects how communication of relevant information may affect the decision to intervene and is presented as a dummy variable that takes the value of –1 (the message entails sales by the central bank); 0 (the message is neutral regarding the market intervention); and 1 (the message entails purchases by the central bank).[20,21,22] Finally, u_t is the error term. All variables are weekly and standardized.

Second Stage: Exchange Rate Equation

The aim of the second stage of this estimation process is to link movements in the exchange rate to central bank intervention, using the forecast values of the

[17] Twelve de facto reaction functions are estimated; they depend on the type of intervention and the type of agent.

[18] Adler and Tovar (2014) focused on purchases of foreign exchange only; this part of the document treats net purchases and net sales of foreign exchange separately to investigate the existence of different motives to intervene according to an expected appreciation or depreciation effect.

[19] The dependent variable is truncated, for it takes either zero or a specific value that can be positive (net purchases) or negative (net sales). In this chapter, once the dependent variable is standardized, although still truncated, it becomes a continuous variable.

[20] See the real exchange rate model in Annex 13.2.

[21] Adler and Tovar (2014) also include reserve assets over short-run debt to capture precautionary motives; that data was unavailable for Uruguay.

[22] Those values correspond to monthly data; see Annex 13.2.

reaction function previously estimated as an instrument. In that way, the analysis uses a variable that is highly correlated with foreign exchange intervention but relatively free of the endogeneity problem reported in the literature. It also includes other variables as controls: interest rate differentials, sovereign spreads, commodity price shocks, and the US trade-weighted exchange rate.

Formally,

$$e_t = max\left\{0, f\left[\left(i_t - i_t^*\right), S_t, P_t^E, P_t^S, P_t^B, \hat{I}_t, DUS_t\right]\right\}, \tag{13.5}$$

where e_t stands for the log of the nominal bilateral exchange rate (Uruguayan pesos against the US dollar); i_t is the domestic 30-day nominal interest rate for the peso-nominated yield curve; i_t^* is the effective federal funds rate, and the difference between them shows the interest rate spread; S_t is the EMBI differential for Uruguayan sovereign bonds; P_t^E, P_t^S, and P_t^B are the logs of the international price indexes for energy, soybean, and beef (basic products for Uruguay that may influence the evolution of the exchange rate); $\hat{I}_t$ is the amount of forecast intervention from the first stage of the estimation procedure; and DUS_t is the trade-weighted nominal exchange rate index for the United States, which has a direct correlation with capital flows in emerging market economies.[23,24,25] All variables are weekly and standardized for January 2005 to December 2017. Optimal lags are selected using information criteria.

The specific model approach used to estimate the exchange rate equation depends on the order of integration of the forecast intervention variable. Because only $\hat{I}_t$ is stationary, the analysis has to deal with $I(0)$ and $I(1)$ variables in the same system. Assuming that the intervention shock has transitory effects on the other variables, the analysis pursues a VAR in differences for the $I(1)$ series and the forecast intervention series.[26]

The analysis of the order of integration of the variables involved at this stage is presented in Table 13.2.3 in the annex.

Estimation Results

The estimations for the first stage, displayed in Table 13.2, suggest that interventions respond de facto to several motives, and that the willingness to intervene depends not only on the actual sign of the intervention—whether net purchases or net sales—but also on the type of it.[27] In effect, short-term movements of the exchange rate, nominal appreciation velocity, and precautionary concerns are the

[23] The interest rate was not the monetary policy instrument in Uruguay for the whole period.

[24] The correlation between the interest rate spread and the EMBI differential is 0.0378 for the sample period.

[25] Tovar and others (2014); on the other hand, Druck and others (2018) show a high correlation between US dollar real effective exchange rate and commodity prices.

[26] This study does not apply a structural analysis. For a more detailed explanation of the econometric issues when modeling with a mixture of $I(1)$ and $I(0)$ variables, see Fischer and others (2013).

[27] Aggregate purchases and aggregate sales results are not presented here.

most common a priori reasons for intervention. The communication variable does have a role in the level of interventions, particularly when there is currency appreciation, and the objective is to raise the exchange rate; when sterilized interventions are considered, the communication variable is always significant both when the final objective is either to raise or decrease the exchange rate. In line with Adler and Tovar's previous findings, it seems that real exchange rate misalignments were a reason for intervening only in the case of central bank sales. Intra-week volatility appears to be a driving force in the reaction function for indirect intervention through net purchases in the foreign exchange market.

One way to analyze the effectiveness of interventions in changing the level of the Uruguayan peso/US dollar rate is to calculate impulse-response functions. To recover the structural intervention shock, this study applies Choleski factorization, which implies a specific ordering of the variables, ranging from the most to the least exogenous. The trade-weighted US dollar index is determined once international commodity prices are set; in addition, international prices of energy and beef Granger dictate the US dollar index in the United States. The nominal bilateral exchange rate Uruguayan peso/US dollar is contemporaneously affected by the trade-weighted US dollar index but not the other way around; Uruguay is a small open economy and a price-taker from global markets. The interest rate spread is contemporaneously affected by both international conditions and the value of the exchange rate, while Uruguayan country risk is determined after them. Interventions respond to all the previous variables and the direction of the relation is known, for central banks tend to react to dampen movements in the exchange rate rather than the opposite.[28] As a result, the ordering of the variables is:

$$\left\{ \left[P_t^E, P_t^S, P_t^B, DUS_t, e_t, \left(i_t - i_t^*\right), S_t, \hat{I}_t \right] \right\} \tag{13.6}$$

The estimations for the second stage reveal either a short-lived and small effect of interventions (purchases) on the nominal exchange rate or no effect at all, in line with the results previously obtained with monthly data. For example, when only sterilized foreign exchange purchases are considered, additional intervention of 1 percent of GDP will increase the nominal exchange rate by 0.5 percent maximum by the first week following the change.[29,30] Then the effect vanishes.

Similar results are obtained when the central bank is the agent in charge of the intervention. In effect, an increase of 1 percent of GDP in central bank nonsterilized foreign exchange purchases will increase the nominal exchange rate by 1.4 percent the following week. After that, the effect disappears.

Indirect intervention, through export prefinancing and local currency securities in US dollars, or exchange forwards settlements, among other operations, has a smaller (0.7 percentage) although longer impact (12 weeks) on the nominal

[28] Recall that expected de facto intervention is used as an instrument for actual intervention in order to identify interventions properly.

[29] As in Adler and Tovar (2014).

[30] If we consider global intervention, the effect is similar but rather smaller.

TABLE 13.2.

Reaction Function Estimates of Types of Intervention, January 2005 to December 2017

	BCU	Direct	Indirect	Sterilized	Nonsterilized
Purchases					
Constant	−0.0358	−0.0106	−0.0240	−0.0202	0.0028
	(0.5769)	(0.8639)	(0.6981)	(0.7810)	(0.9957)
$D(e_{t-1})$	−1.6432***	−0.2124***	—	−0.0857*	—
	(0.0048)	(0.0000)		(0.0606)	
$reer_t$-$reer_t^{eq}$	—	—	—	—	—
Δ_t	0.1899***	0.2425***	0.1520***	—	0.1553***
	(0.0016)	(0.0000)	(0.0003)		(0.0058)
σ_t	—		−0.0995**	—	—
			(0.0281)		
R_t^{M2}	−0.1723**	−0.1821***	—	—	0.1197**
	(0.0144)	(0.0079)			(0.0403)
C_t	4.1587***	—	3.1419**	2.9591***	—
	(0.0000)		(0.0156)	(0.0929)	
R^2	0.1295	0.1352	0.0562	0.0268	0.0409
Adjusted R^2	0.1243	0.1313	0.0520	0.0239	0.0380
Durbin Watson	1.1640	1.1883	1.3840	0.4245	0.7986
No. of observations	674	674	674	674	674
Sales					
Constant	−0.0081	−0.0228	−0.0073	−0.0245	−0.0063
	(0.9057)	(0.5415)	(0.9089)	(0.5052)	(0.9110)
$D(e_{t-1})$	−0.0754**	−0.1604***	—	−0.1414***	—
	(0.0200)	(0.0000)		(0.0001)	
$reer_t$-$reer_t^{eq}$	—	0.1077**	—	—	—
		(0.0218)			
Δ_t	0.2514***	0.2534***	0.2320***	—	0.1194**
	(0.0054)	(0.0000)	(0.0043)		(0.0299)
σ_t	—	—	—	—	—
R_t^{M2}	—	−0.0857**	—	−0.2483***	—
		(0.0243)		(0.0000)	
C_t	—	1.8975**	—	2.6746***	—
		(0.0200)		(0.0009)	
R^2	0.0666	0.0635	0.0525	0.1138	0.0139
Adjusted R^2	0.06379	0.0601	0.0511	0.1086	0.0125
Durbin Watson	1.2582	1.1011	1.4300	0.4419	1.3338
No. of observations	674	674	674	674	674

Source: Authors' calculations.
Note: Estimations were made using weekly normalized data. Standard errors that are robust to autocorrelation and heteroskedasticity appear in parentheses.
*$p < .1$; ** $p < .05$; *** $p < .01$.

Urguayan peso/US dollar rate, while direct purchases in the spot market and sterilized sales do not have a statistically significant effect (see Table 13.3 and Annex 13.1 for the impulse-response functions (IRFs)).

The results suggest a nonlinear relation between interventions and exchange rate performance. In effect, a purchase in the foreign exchange market of 1 percent of GDP would increase the exchange rate by 1.4 percent the following week,

TABLE 13.3.

Types of Main Effects of Interventions, 2005–17

		First Effect after Impulse		Max Effect after Impulse		Last Effect after Impulse	
Increase in	Impulse (% GDP)	One Week[1]	Amount[2]	One Week[1]	Amount[2]	One Week[1]	Amount[2]
Purchases	1	1	1.4	1	1.5	1	1.5
Sales	1	1	−32.5	4	−42.2	4	−42.2
BCU							
Purchases	1	1	1.4	1	1.4	1	1.4
Sales	1	1	−16.8	1	−16.6		−3.2
Direct							
Purchases	1	—	NSSc	—	NSSc	—	NSSc
Sales	1	1	−14.9	1	−14.7	12	0.1
Indirect							
Purchases	1	1	0.7	2	0.8	12	0.2
Sales	1	2	−31.5	3	−38.9	21	−12.9
Sterilized							
Purchases	1	1	0.5	—	—	—	—
Sales	1	—	NSSc		NSSc	—	NSSc
Nonsterilized							
Purchases	1	6	0.7	19	0.9	111	0.5
Sales	1	1	−30.4	3	−37.2	20	−14.5

Source: Authors' calculations.
Note: NSSc = nonstatistically significant results, with correct sign.
[1] "Amount" shows the percentage points of nominal Uruguayan pesos/US dollar change.
[2] This shows the change of nominal Uruguayan pesos/1 US dollars in percentage points of GDP.

while a sale in the foreign exchange market of 1 percent of GDP would decrease the exchange rate by 32.5 percent.[31] In other words, the effort needed in terms of GDP to get nominal foreign exchange depreciation through foreign exchange intervention is several times that required to appreciate it. Nevertheless, what really matters are the effects after open market operations are done. Sterilized interventions show that a purchase of 1 percent of GDP would increase the nominal exchange rate by 0.5 percent only in the week following the intervention, while there could be a small effect on the exchange rate because of foreign exchange sales (it is not statistically significant). Almost all of the impact of an intervention occurs during the week it is conducted, which confirms the idea that central banks typically lean against the wind.

In a nutshell, it can be said that central bank foreign exchange interventions have a short-lived impact, whereas indirect interventions have smaller but long-lasting effects; for a very short time that can only be seen on a weekly basis, sterilized foreign exchange intervention barely affects the exchange rate, while the remaining nonsterilized foreign exchange interventions are the ones responsible for the higher, although still small effects on the exchange rate that last longer.

[31] This result also reflects the strong appreciation of the US dollar in global markets in the sample.

Obviously, if no sterilization were done, domestic currency depreciation/appreciation induced by foreign currency purchases/sales would be greater.[32]

CONCLUSION

In this chapter's study of the effects of foreign exchange interventions in Uruguay during 2005–17, the exchange rate sampled arguably reflects the highest flexibility in the country's economic history. Yet intervention has been the rule rather than the exception, largely because of undue influence in an open economy like Uruguay's of unprecedented volatility in the international environment.

Authorities have been very vocal about the need to dampen the impact of this volatility in Uruguay and have been trying to avoid both price or financial instability. In doing so, they have used several avenues to intervene in the foreign exchange market. The main interest in this chapter therefore was to identify how the exchange rate responds to different types of intervention, in addition to the effectiveness itself.

Taken together, the results of this study seem to suggest that this expressed concern of the authorities with exchange rate volatility can be rationalized as a concern over the impact of exchange rate short-term movements, nominal exchange rate appreciation/depreciation velocity, and real exchange misalignment adjustments. Further testing of this hypothesis will be a topic of the research agenda.

The results also suggest that the use of foreign exchange intervention, together with other monetary and financial tools, helped dampen the adverse effect of large swings in capital flows and related domestic portfolio changes in terms of the economic fundamentals, and excessive volatility in relative prices, currency markets, and interest rates.[33]

In reaching its conclusion, the analysis applied different methodologies to different datasets, both monthly and weekly.[34] This allowed more detailed analysis of foreign exchange movements induced by the interventions and more precisely determined the duration of the effect, if any. The analysis also distinguished between purchases and sales of foreign exchange (on a weekly basis) to search for different reasons to intervene in each situation.

In addition, the endogeneity of exchange rates and interventions has been critical in the investigation. As Kearns and Rigobon (2005) point out: "...failing to account for the endogeneity, when central banks lean against the wind and trade strategically, will likely result in a large downward bias to the coefficient on

[32] Results are sensitive to US dollar evolution in global markets during the time of analysis.

[33] This is an asset and liability approach to the integrated balance sheet of the public sector and reserve requirements on nonresident investments in public debt in the primary market.

[34] Weekly datasets are from January 2005 to December 2017, while monthly datasets cover March 2007 to December 2017, since the one-day interest rate was the monetary policy instrument.

contemporaneous intervention explaining the negative coefficient frequently obtained." Here, the analysis adopted two strategies to deal with this problem, depending on the dataset frequency. For monthly data, the order of the variables in the VAR was determined following a specified theoretical framework. For weekly data, the analysis followed the Adler and Tovar (2014) two-stage estimation process. In the first stage, a de facto reaction function for the central bank was estimated; in the second stage, predicted values of this reaction function were used as instruments in the estimation of a behavioral equation for the exchange rate.[35]

More specifically, the results suggest several conclusions, as outlined in the introduction. It is worthwhile to reiterate the results:

1. Interventions affect the level of the exchange rate, but the effect is short-lived.
2. While the effect of indirect interventions appears with the expected sign, and is statistically significant, direct interventions get a meaningful response through foreign exchange sales, while purchases "just" prevented the peso from further appreciation.
3. Sterilized intervention does not seem to have an effect on the level of foreign exchange longer than one week after foreign exchange purchases, explaining why no effect is found when monthly data is used.
4. Interventions have asymmetric effects on the foreign exchange; that is, purchases of foreign exchange (that tend to increase the exchange rate) are more costly in terms of GDP than sales of foreign exchange (that tend to decrease the foreign exchange).
5. Communication to the public of relevant information regarding the value of the exchange rate seems to play a role in the motives of de facto intervention.
6. The central bank seems to worry about the level of the foreign exchange and about the appreciation velocity of the foreign exchange, rather than its volatility.
7. Real exchange rate misalignments seem to have been a reason for intervening only in the case of central bank sales.
8. And last but not least, as the flip side of sterilized interventions is the increase in the stock of monetary regulation securities, these excess reserves are a macroprudential buffer that has associated costs because of interest rate differentials between Uruguay and the United States.

[35] Twelve de facto reaction functions are estimated, depending on the type of intervention and the type of agent.

ANNEX 13.1. MONTHLY DATA

TABLE 13.1.1.

Descriptive Statistics

	E^{Uy}_t	$NFXP_t$	$NFXP\_STD_t$	$NFXP\_DIR_t$	$NFXP\_IND_t$	$NFXP\_STER_t$	$NFXP\ NON\_STER_t$
Mean	23.272	82.553	−0.001	18.368	17.961	50.816	31.922
Median	22.257	112.160	0.127	0.000	0.000	90.850	13.855
Maximum	32.133	595.430	2.217	384.520	534.560	568.330	669.080
Minimum	18.428	−969.460	−4.550	−378.800	−903.530	−882.870	−373.100
Standard deviation	3.795	235.119	1.017	83.802	174.228	244.035	169.456
Skewness	0.695	−1.696	−1.696	0.597	−0.920	−0.982	0.392
Kurtosis	2.228	8.846	8.846	10.173	12.679	4.687	4.112
Jarque-Bera	13.811	249.335	249.335	288.651	591.838	36.870	10.178
Probability	0.001	0.000	0.000	0.000	0.000	0.000	0.006
No. of observations	131	131	131	131	131	132	132

Source: Authors' calculations.

TABLE 13.1.2.

Unit Root Analysis

	Augmented Dickey-Fuller Test for Unit Root	
Variable	**MacKinnon *p*-value**	**Test Statistic**
E^{Uy}_t	0.765	−0.967
E^{USA}_t	0.631	−1.296
E^{Uy}_t	0.866	−0.621
$NFXP_t$	0.017	−3.261**
π^e_t	0.011	−3.390**
i^{Uy}_t	0.043	−2.922**
i^{USA}_t	0.003	−3.839**
d^e_t	0.019	−3.218**
VIX_t	0.098	−2.576*
ρ^{EME}_t	0.012	−3.376**
ρ^{UY}_t	0.064	−2.781*
No. of observations	130	

Source: Authors' calculations.

Note: For E^{Uy}_t, the 1 percent, 5 percent, and 10 percent critical values are −3.501, −2.888, and −2.578, respectively.

*$p < .10$; **$p < .05$; ***$p < .01$.

TABLE 13.1.3.

Cointegration Analysis

Unrestricted Cointegration Rank Test (Trace)

Hypothesized Cointegration Equations	Eigenvalue	Trace Statistic	5% Critical Value	Probability[2]
None[1]	0.235170	56.63615	42.91525	0.0013
At most one	0.124209	22.58728	25.87211	0.1215
At most two	0.044217	5.743543	12.51798	0.4935

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized Cointegration Equations	Eigenvalue	Maximum Eigenvalue Statistic	5% Critical Value	Probability[2]
None[1]	0.235170	34.04888	25.82321	0.0033
At most one	0.124209	16.84373	19.38704	0.1127
At most two	0.044217	5.743543	12.51798	0.4935

Source: Authors' calculations.

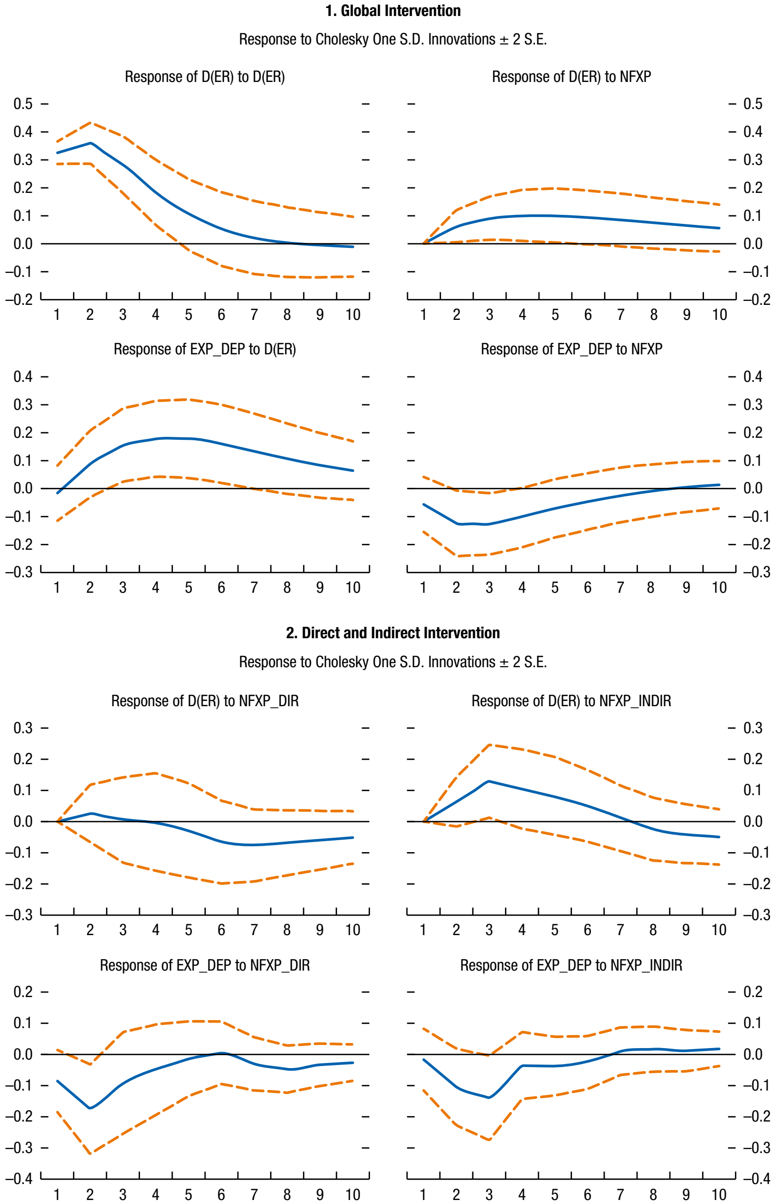
Note: The trace test indicates one cointegrating equation at the 5 percent level, and the maximum eigenvalue test indicates one cointegrating equation at the 5 percent level.

[1] "None" denotes rejection of the hypothesis at the 5 percent level.

[2] See MacKinnon-Haug-Michelis (1999) for the *p*-values.

Figure 13.1.1. Impulse Response Functions: Response of Exchange Rate and Expected Depreciation to Interventions

(Standard deviations of the corresponding impulse)



Source: Authors' calculations.

ANNEX 13.2. WEEKLY DATA

TABLE 13.2.1.

Data Set

Mnemonic	Description	Source	Log	Dif
P^S	Soybean international price	IMF	Y	Y
P^E	Energy international price	IMF	Y	Y
DUS	Trade-weighted US dollar index	FRED	Y	Y
e	Uruguayan pesos/US dollar exchange rate	BCU	Y	Y
$i - i^*$	30-day ITLUP (Uruguayan peso-nominated yield curve) over effective FFR	https://web.bevsa.com.uy/ and FRED	N	Y
S	EMBI Uruguay	República AFAP	Y	Y
DES_REER	REER misalignment	Authors' calculation	Y	N
Δ	Uruguayan pesos/US dollar appreciation/ depreciation velocity	Authors' calculation	N	N
σ	Nominal exchange rate volatility	Authors' calculation on BCU data	N	N
C	Communication dummy	Authors' calculation	N	N
R^{M2}	Reserves to M2 ratio	Authors' calculation on BCU data	N	N
BCU_PUR	Intervention (purchases) done by BCU[1]	BCU	N	N
BCU_SALES	Intervention (sales) done by BCU[1]	BCU	N	N
DIR_PUR	Direct intervention (purchases)[1]	BCU	N	N
DIR_SALES	Direct intervention (sales)[1]	BCU	N	N
INDIR_PUR	Indirect intervention (purchases)[1]	BCU	N	N
INDIR_SALES	Indirect intervention (sales)[1]	BCU	N	N
EST_PUR	Sterilized intervention (purchases)[1]	BCU	N	N
EST_SALES	Sterilized intervention (sales)[1]	BCU	N	N
NON_EST_PUR	Nonsterilized intervention (purchases)[1]	BCU	N	N
NON_EST_SALES	Nonsterilized intervention (sales)[1]	BCU	N	N

Source: Authors' calculations.
Note: BCU = Banco Central del Uruguay; EMBI = Emerging Markets Bond Index; FRED = Federal Reserve; República AFAP = Uruguayan state-owned pension fund company.
[1]This is measured as a percentage of GDP.

TABLE 13.2.2

Descriptive Statistics

	P^S	P^E	DUS	e	$i - i^*$	S
Mean	390.2652	141.1646	107.1886	23.41697	1.808031	252.1682
Median	375.2612	132.4080	104.3829	23.39800	2.842216	221.2000
Maximum	622.9135	249.6072	128.4466	32.31200	3.285013	865.2000
Minimum	197.5892	60.64390	94.07466	18.38200	2.130693	112.2000
Standard deviation	103.8388	44.79428	8.676582	3.488442	1.822798	112.2770
Skewness	–0.006670	0.246069	0.676758	0.633226	–1.233232	2.485051
Kurtosis	2.218970	1.776925	2.363292	2.485153	2.855085	10.54785
Jarque-Bera	17.13604	48.81201	62.83378	52.48684	171.4332	2293.623
Probability	0.000190	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	263038.7	95144.93	72245.09	15783.04	1218.613	169961.4
Sum of squares deviation	7256621.	1350393.	50665.51	8189.892	2236.105	8483916.

	DES_REER	DES_C	R^{M2}		
Mean	8.32E-05	4.38E-06	0.006345	0.007206	–0.024768
Median	–0.001664	4.57E-05	0.002456	0.000000	–0.041530
Maximum	0.098689	0.000364	0.055120	0.285714	1.925887
Minimum	–0.095291	–0.000373	5.70E-06	–0.285714	–1.887973
Standard deviation	0.035362	0.000159	0.009316	0.046166	1.008014

	BCU_PUR	BCU_SALES	DIR_PUR	DIR_SALES
Mean	0.044255	–0.017752	0.045964	–0.007136
Median	0.009560	0.000000	0.024794	0.000000
Maximum	0.535780	0.000000	0.491070	0.000000
Minimum	0.000000	–1.640539	0.000000	–0.334517
Standard deviation	0.072237	0.084930	0.063377	0.032109
Skewness	2.899842	–12.19151	2.485731	–6.030426
Kurtosis	15.15568	208.5092	13.25778	45.57295
Jarque-Bera	5094.228	1202768.	3649.076	54984.92
Probability	0.000000	0.000000	0.000000	0.000000
Sum	29.82779	–11.96464	30.97964	–4.809911
Sum of squares deviation	3.511824	4.854446	2.703165	0.693839

	INDIR_PUR	INDIR_ SALES	EST_PUR	EST_SALES	NON_EST_ PUR	NON_EST_ SALES
Mean	0.028257	–0.020006	0.079723	–0.052296	0.070790	–0.052012
Median	0.000000	0.000000	0.041668	0.000000	0.016631	0.000000
Maximum	0.958648	0.000000	0.449949	0.000000	0.690899	0.000000
Minimum	0.000000	–1.640539	0.000000	–0.641600	0.000000	–1.220810
Standard deviation	0.067219	0.094017	0.093340	0.118820	0.118310	0.103809
Skewness	6.252966	–11.50790	1.327974	–2.608135	2.394146	–4.594779
Kurtosis	67.03102	175.0000	4.541375	9.817313	9.084095	39.92522
Jarque-Bera	119533.1	845693.6	264.8230	2069.327	1683.426	40662.41
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	19.04547	–13.48371	53.73317	–35.24724	47.71254	–35.05593
Sum of squares deviation	3.040911	5.948737	5.863377	9.501601	9.420226	7.252500

Source: Authors' calculations.
Note: For each variable, there were 674 observations.

TABLE 13.2.3

Unit Root Analysis

	ADF Test Statistic		MacKinnon (1996) One-Sided Critical Values			
Variable	***t*-Statistic**	***p*-value**	**1% Level**	**5% Level**	**10% Level**	**Order of Integration**
P^S	−2.0476	0.2665	−3.4403	−2.8658	−2.5691	1
P^E	−2.2133	0.2018				1
DUS	−1.2035	0.6747	−3.4397	−2.8656	−2.5690	1
e	−0.7404	0.8342				1
$i - i^*$	−1.4121	0.5773				1[1]
S	−2.8551	0.0513				1[1]
D(P^S)	−7.2636***	0.0000	−3.4403	−2.8658	−2.5691	0
D(P^E)	−6.1387***	0.0000				0
D(DUS)	−19.6386***	0.0000	−3.4397	−2.8656	−2.5690	0
De	−19.5813***	0.0000				0
D($i - i^*$)	−4.7781***	0.0001	−3.4398	−2.8656	−2.5690	0
D(*S*)	−10.2883***	0.0000				0
I_PUR[2]	2.2320**	0.0259	−2.5684	−1.9413	−1.6164	0
I_SALES[2]	−2.2320**	0.0259				0
I_BCU_PUR	−4.2558***	0.0006	−3.4399	−2.8556	−2.5690	0
I_BCU_SALES[2]	−2.9789**	0.0374				0
I_DIR_PUR	−3.1345**	0.0246				0
I_DIR_SALES	−3.5069***	0.0081				0
I_IND_PUR	−4.5221***	0.0002				0
I_IND_SALES[3]	−4.0392***	0.0013				0
I_EST_PUR	−15.1229***	0.0000				0
I_EST_SALES	−3.8515***	0.0026				0
I_NON EST_PUR[2]	−2.3126**	0.0210	−2.5684	−1.9413	−1.6164	0
I_NON EST_SALES	−3.1914**	0.0209	−3.4400	−2.8657	−2.5690	0

Source: Authors' calculations.

** $p < .05$; *** $p < .01$.

[1] The variable seems to be I(0) with at least one break, but it was treated as I(1) for operational reasons.

[2] The Elliott, Rothenberg, and Stock DF-GLS test was applied.

[3] The Phillips-Perron unit root test was applied.

TABLE 13.2.4

Real Exchange Rate Model				
Variable	**Coefficient**	**Standard Error**	***t*-Statistic**	**Probability**
Constant	5.124394	0.048779	105.0533	0.0000
Net interest rate	–0.015596	0.001352	–11.53773	0.0000
Government consumption-over-GDP ratio	–0.526984	0.447669	–1.177174	0.2395
Linear trend	–0.000978	8.19E-06	–119.4008	0.0000
R^2	0.968463	Mean dependent variable		4.579273
Adjusted R^2	0.968320	Standard deviation dependent variable		0.196787
Standard error of regression	0.035026	Akaike information criterion		–3.859467
Sum of squared residuals	0.812153	Schwarz criterion		–3.832432
Log likelihood	1289.203	Hannan-Quinn criterion		–3.848993
F-statistic	6776.326	Durbin-Watson statistic		0.015912
Probability (*F*-statistic)	0.000000			

Source: Authors' calculations.

Note: The dependent variable is L_REER; the method is a least squares sample (adjusted): January 5, 2005, to October 4, 2017; and the number of included observations are 666 after adjustments.

Figure 13.2.1. Impulse Response Functions: Response of Exchange Rate to Interventions using Choleski Identification

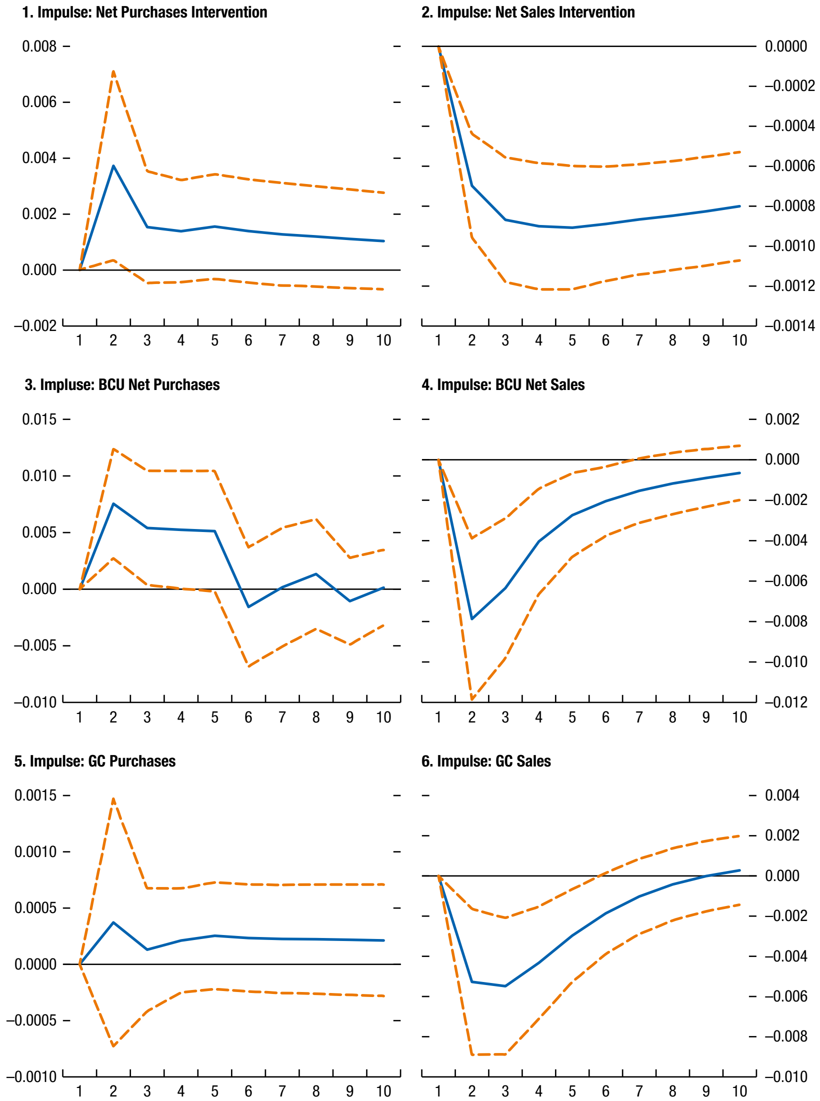


Figure 13.2.1. Impulse Response Functions: Response of Exchange Rate to Interventions using Choleski Identification
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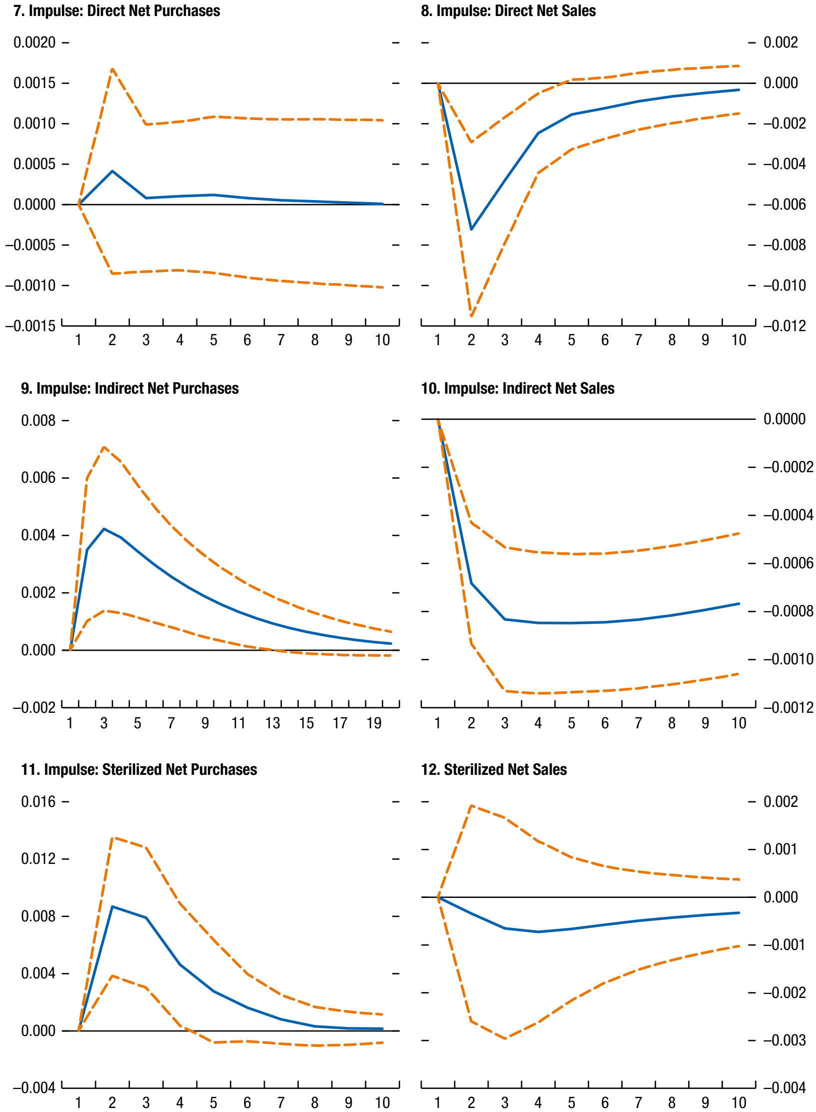
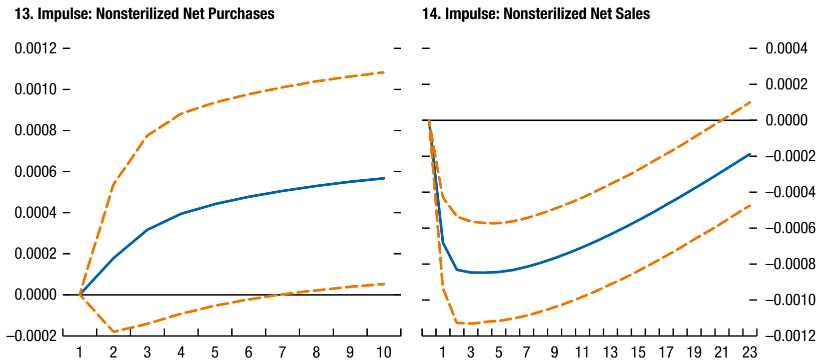


Figure 13.2.1. Impulse Response Functions: Response of Exchange Rate to Interventions using Choleski Identification
(continued)



Source: Authors' calculations.
Note: BCU = Banco Central del Uruguay.

ANNEX 13.3. INTERVENTIONS IN URUGUAY

TABLE 13.3.1.

Interventions in Uruguay

Institution	Type of Intervention	Instrument	Comment about the Instrument
Central Bank	Direct/indirect Sterilized/ nonsterilized	Purchases/sales in the spot market	—
		Monetary Regulation Bills (*Letras de Regulación Monetaria*)	Most common instrument to sterilize purchases
		Certificates of deposit	Mainly used during interest rate target period
		Integration in US dollars	From 2008 to 2017 intermittently
		Derivatives (SWAPS or financial contracts, futures)	Notably with public energy enterprises
		Bank reserve requirements	Increased and reduced (in 2016 and 2017, for example)
		Capital controls	Started in August 2012 and lasted until May 2015 (there were modifications in the meantime)
Ministry of Economy	Direct/indirect Nonsterilized	T-bills	
		Bonds	
		Purchases/sales to central bank	
		Exports prefinancing	Handled by the central bank
Bank of the Republic (state-owned)	Direct	Purchases/sales in the spot market	

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Index

This book is a wonderful reference for anyone interested in foreign exchange markets. While the focus is on Latin America, the analytical, general policy, operational, and technical issues studied in these chapters have global appeal. For academics, it brings an older literature up to date in the context of the shift to greater exchange rate flexibility and the comparatively newer practices of central banks with inflation targeting. For policymakers, it is essential reading, as it provides a discussion of both general considerations in intervention strategies and country case studies with a rich array of experiences. For financial market participants, understanding central banks and their policies forms an integral part of informed investment decision making.

CARMEN M. REINHART

Minos A. Zombanakis Professor of the International Financial System at Harvard Kennedy School

This book helps fill an important information gap. And it does it with evidence and firsthand policymaking experience, with a focus on Latin America. Both practitioners and academics would benefit enormously from reading the chapters of this book. There is still an apparent void between theory and practice when dealing with emerging markets foreign exchange intervention. In theory, pure floating, with no intervention, suits well an inflation-targeting regime. In practice, most emerging markets accumulate reserves and intervene in one way or another in their markets, especially in moments of stress. Why and when should emerging markets intervene? Helping markets function and providing liquidity in moment of stress is part of the answer. But how rare should interventions be? And how should one intervene? Should interventions occur in the spot or in the forward markets? How should inflation-targeting regimes be run when interventions are necessary? The discussion of these and other related topics makes this book an important reference for policymakers, for emerging markets investors, and for those studying international finance.

ILAN GOLDFJAN

Governor of the Central Bank of Brazil

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