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Effects of Foreign Exchange Intervention under Public Information: The Chilean Case

In 1982 Chile experienced the traumatic collapse of the fixed exchange regime in place since 1979. After successive devaluations, the regime finally evolved into the adoption of a band in 1984. Although the band experienced several changes with time, most of them were pointed toward increasing degrees of flexibility. This trend towards flexibility increased in the 1990s, when the Central Bank of Chile became independent and aimed its efforts at reducing inflation through the gradual adoption of an inflation-targeting framework. The exchange rate commitment became increasingly secondary vis-à-vis the inflation objective, and the band was ultimately abandoned in September 1999 with the implementation of a floating regime.[1]

Exchange rate interventions were a common feature of policy while the band was in place. They have continued in the more than four years since the adoption of the float. The Central Bank of Chile defined explicit intervention periods in both 2001 and 2002, in response to what were considered exceptional circumstances that put the exchange rate market under significant stress.

The two-corner hypothesis, which suggests that currency regimes worldwide are shifting toward either extremely tight commitments or

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We wish to thank Oscar Landerretche, Roberto Rigobon, Klaus Schmidt-Hebbel, Rodrigo Valdés, and the members of the Board of the Central Bank of Chile for valuable comments. We are also indebted to Rómulo Chumacero, Alberto Naudon, and Jorge Pérez.

1. For a detailed description of Chile's exchange rate policies in recent years, see Morandé and Tapia (2002).

floating regimes, has focused new attention on the reasons for and effectiveness of exchange market intervention.[2] When an explicit currency commitment exists, intervention has an obvious role to play, naturally using its tools (such as reserves and interest rates) to validate this commitment. Things become fuzzier, however, when one considers the appropriate role of intervention under flexible exchange rate arrangements. Interventions are frequent even in countries with allegedly free-floating regimes, where the market is supposed to determine the parity on its own. A clean float is a rarity: almost every regime that describes itself as floating involves intervening in the exchange market to some degree.[3]

This paper does not analyze whether interventions are efficient in terms of welfare. Given the decision to intervene in the exchange market, our goal is to determine whether central bank interventions can have significant effects on the exchange rate's level and trend. We analyze these effects for the Chilean economy, using daily data since 1998 and intraday data for 2001.

In the next section, we present a simple framework of how intervention decisions are made and through which channels they affect the exchange rate. The subsequent section contains a description of the three intervention episodes under study (January 1998 to September 1999, August to December 2001, and October 2002 to February 2003). We then use time series methodologies to provide an empirical analysis. The final section presents policy implications and conclusions.

Foreign Exchange Intervention

The analysis of foreign exchange intervention usually focuses on sterilized interventions. Nonsterilized interventions are equivalent to changes in monetary policy, and they thus have an unambiguous effect on the exchange rate market. The effects of sterilized interventions are less obvious, since the money base and domestic interest rates remain unaltered because of offsetting operations with domestic securities. Under free

2. Eichengreen (1994); Obstfeld and Rogoff (1995).

3. See, for example, Calvo and Reinhart (2002). Neely (2001) shows the results of a survey of a group of over twenty developed and developing countries, including the Group of Seven. Of this sample, only New Zealand abstained completely from intervening in the exchange market between 1990 and 2000.

capital mobility, successful sterilized intervention implies that the central bank is able to break the so-called impossible trinity (that is, the impossibility of a fixed exchange rate, active monetary management, and an open capital account all at once) by independently conducting monetary and exchange rate policies.

Channels

The theoretical literature identifies at least three mechanisms through which the exchange rate can change after sterilized interventions: portfolio, signaling, and information channels. These channels are not mutually exclusive, and they may work simultaneously under certain conditions. Next we present a brief explanation of these channels.[4]

In the portfolio channel, under the assumption of imperfect substitution between domestic and foreign assets, changes induced by the foreign exchange interventions in the relative supply of domestic and foreign assets force an adjustment in the investors' portfolio, which in turn alters the exchange rate. The size of the effect depends on the relative quantities of assets involved. Most intervention episodes involve small amounts; therefore, many authors are skeptical of the practical relevance of this channel. Empirical studies fail to deliver a clear answer.[5]

The signaling channel reflects the fact that intervention gives away information on future monetary policy: a sale of foreign currency anticipates a tighter monetary stance; a purchase anticipates a relaxation in monetary policy. Market agents interpret the signal and adjust their positions in domestic and foreign currency, thereby affecting the exchange rate.[6] This channel has important conceptual differences with the portfolio mechanism. First, it does not break the impossible trinity, since the effect of intervention is conditional on the credibility of the signaled path for future monetary policy. Monetary policy and intervention activities are related: a signal that is not validated by policy actions, or that is not credible given the policy framework, will be ineffective or quickly reversed. Moreover, the subsequent reduction in credibility will lower the impact of future interventions. The sterilization of today's intervention must therefore be reversed sometime in the future. In that case, this channel is

4. See Tapia and Tokman (2003) for a more detailed discussion.
5. Domínguez and Frankel (1993); Evans and Lyons (2001).
6. Mussa (1981).

equivalent to a nonsterilized intervention with a time lag. In an inflation-targeting regime, for example, intervention signals must be consistent with the commitment to a low inflation rate. The impossible trinity remains unattainable, because the central bank cannot pursue conflicting targets for both the exchange rate and inflation.

A second implication of this mechanism is that only operations performed by authorities with power over the conduct of monetary policy should have an effect. If the central bank has full and credible autonomy from the government, intervention conducted by the central government should have no impact under this mechanism. The final implication is that interventions must be perceived as such by the general public, given that this channel operates directly on agents' expectations.

The third channel—the information channel—is a particular case of the signaling mechanism. Unlike the earlier two channels, however, the information channel assumes the existence of significant exchange rate misalignments. Deviations from equilibrium are caused by the presence of speculators who, in contradiction of Friedman's classic argument, destabilize the foreign exchange market and move the exchange rate away from macroeconomic fundamentals.[7] These agents, whose presence may be endogenous to the market's behavior, can introduce persistent deviations of the exchange rate from the long-run trend. These misalignments can become a short-run equilibrium in certain circumstances. In this case, the signal provided by intervention must not necessarily be validated by actual monetary policy action. If monetary policy is fully credible, the sole threat of adjusting interest rates—given by the intervention signal—may suffice to move the market, which interprets the signal as an indication that the central bank will change the interest rate if the parity continues its perceived deviation from equilibrium.

Instruments

Most studies focus on spot interventions, since countries usually rely on spot purchases or sales to implement their exchange rate intervention policy. Direct currency operations, however, are not the only policy instru-

7. Friedman (1953). This vision has come mainly as a result of the poor predictive power of theoretical foreign exchange models based on macroeconomic variables (Frankel and Rose, 1995).

ments available to central banks. In principle, these could also operate through operations in both foreign- and domestic-currency papers.

The authorities may be able to affect the market not only through actual intervention operations, but also via public announcements regarding them. This is, after all, the mechanism operating in two of the channels: interventions have no effect per se, but work through the informational element contained in them. Formal or informal public announcements reveal relevant information to the market on, for example, the expected stance of future monetary policy or expected changes in the relative portfolio of domestic and foreign assets; the market should adjust accordingly, before actual events occur. In the case of Chile, announcements became a formal instrument in the intervention policy framework. In the United States, by contrast, the speeches and announcements by Alan Greenspan are taken very seriously by the market, even though they are not supposed to be formal announcements of policy.

The effect of a particular announcement depends largely on its credibility and feasibility. Credibility is based on the reputation of the authority making the announcement. A credible announcement will immediately affect expectations and be reflected in market prices, whereas agents will dismiss a noncredible announcement as irrelevant noise. The effect of the announcement also depends on the feasibility of implementing the policies that are being put forth. For example, under the assumptions of the portfolio channel, an announcement regarding future interventions will only be deemed credible if the agents believe that the reserves held by the central bank are sufficient for engaging in active market participation.

How do announcements operate? The day the authority reveals information regarding its future plans—ranging from an informal comment on the economy's current state and policy perspectives to a formal policy announcement—expectations are formed regarding the authority's future actions. In the particular case of intervention policies, these could involve expectations on future monetary policy (in the case of the signaling channel, the announcement should have the same effect as an actual exchange rate intervention) or an expected portfolio adjustment (associated with the expected value of interventions in the portfolio channel). Such expectations should lead the market to adjust, with prices reacting instantaneously, before any actual events occur. As this effect is based on expectations, additional adjustments in prices are likely to occur over

time, as expectations are revised in light of new developments and the authority's own actions. For example, if the authority failed to follow through on its commitment, its credibility would be damaged and the initial effects associated with the announcement would be reversed.

Analytical Framework

This section presents a simple, sketched analytical framework of the relevant variables in order to provide a better illustration of the mechanisms and instruments associated with the effect of interventions. These equations also illustrate the empirical problems associated with the estimation of intervention effects, which are described in the next section.

The first equation describes the behavior of the exchange rate:

$$e_t = f\left(\mathbf{X}_t, S_t, B_t, \mathbf{X}^e_{t+n}, \sum S^e_{t+n}, \sum B^e_{t+n}\right),$$

where e_t is the exchange rate (either in levels or in first differences). The exchange rate is assumed to depend on a set of macroeconomic variables, in present and expected value ($\mathbf{X}_t$ and $\mathbf{X}^e_{t+n}$), and on intervention variables (S_t being spot interventions and B_t dollar denominated bonds), both in present and expected value.

Announcements—the third instrument of intervention—determine the expected level of spot interventions and bond sales. The extent of the impact of a certain announcement on future expectations depends, as mentioned earlier, on the formality and preciseness of the commitment associated with them and on the central bank's credibility. Expectations regarding future interventions also depend on expected and actual macroeconomic developments and on the central bank's previous intervention behavior:[8]

$$\sum S^e_{t+n} = f\left(A_t, \mathbf{X}^e_t, \mathbf{X}_t, \sum S_{t-n}, A_{t-n}\right) \text{ and}$$

$$\sum B^e_{t+n} = f\left(A_t, \mathbf{X}^e_t, \mathbf{X}_t, \sum S_{t-n}, A_{t-n}\right).$$

The way the intervention variables affect the exchange rate depends on the specific channel through which they operate. Under the portfolio chan-

8. Including its fulfillment of previous announcements.

nel, the total value of actual and expected sales and purchases of foreign currency directly affects the exchange rate through the actual (expected) change in the agents' portfolios. Under the signaling and information channels, the intervention variables do not affect the exchange rate directly, but rather release information on the set of relevant macroeconomic variables, which then generates the impact on the exchange rate. In the case of the signaling channel, the revealed information involves future monetary policy, which is one of the variables included in the vector $\mathbf{X}^{e}_{t+n}$. In the case of the information channel, the revealed information is the "true" $\mathbf{X}_t$. In fact, the sole announcement could be the relevant variable, since it encompasses the relevant information associated with the two latter channels. That is,

$$\mathbf{X}^{e}_{t+n} = f(S_t, B_t, A_t) \text{ in the case of the signaling channel, and}$$

$$\mathbf{X}_{t+n} = f(S_t, B_t, A_t) \text{ in the case of the information channel.}$$

The above equations provide a stylized description of the operation of the exchange rate market and its reaction to the intervention instruments. These instruments are not exogenous, however, because the central bank arguably makes intervention decisions conditional on the market's behavior. This endogeneity between intervention decisions and exchange rate movements lies at the core of the empirical problems associated with the estimation of intervention equations.

The three instruments available to the central bank require distinct, though related, decision processes. Spot interventions are clearly conducted on a daily basis, and they are thus probably sensitive to the evolution of the exchange rate on the same day in which the operation occurs. This is, precisely, the simultaneity problem between the exchange rate and spot market interventions that is central to empirical studies regarding the impact of intervention policies. Other variables, such as the evolution of the exchange rate in previous days or macroeconomic variables, could also be relevant.[9] Spot intervention decisions probably also present inertia (if, for example, they are conducted under a predefined scheme of intervention in successive days) and depend on the central bank's capability of conducting them (that is, to have sufficient international reserves in the case

9. Particularly if the central bank is concerned about potential exchange rate misalignments.

of dollar sales). The final relevant variables are formal and informal announcements. In fact, the existence of spot interventions may necessarily require a prior formal announcement, as in the case of Chile in 2001 and 2002.

Bond operation decisions are very similar, but—at least in the case of Chile—they are not conditional on daily events, as they are defined on a monthly basis with a publicly announced calendar. Finally, policy announcements similarly are not conditional on daily events. Rather, they reflect the central bank's main concerns regarding the behavior of the exchange rate market, ranging from issues such as liquidity or potential misalignments to excessive volatility.

$$S_t = g\left(e_t, \sum e_{t-n}, \mathbf{X}_t, \mathbf{X}^e_{t+n}, \text{RESERVES}_t, \text{S}_{t-1}, A_t\right);$$

$$B_t = g\left(\sum e_{t-n}, \sum \mathbf{X}_{t-n}, \mathbf{X}^e_{t+n}, A_t\right); \text{and}$$

$$A_t = g\left(\sum e_{t-n}, \sum \mathbf{X}_{t-n}, \mathbf{X}^e_{t+n}\right).$$

Empirical Evidence and Estimation Problems

The empirical evidence on the effects of exchange rate interventions is plentiful, especially for industrial countries. The early studies reach a degree of consensus on the small effect of sterilized interventions on the exchange rate, and Jurgensen's seminal report apparently concludes the debate on the subject.[10] Academic interest was rekindled in the mid-1980s, however, after the apparent success of coordinated interventions following the Plaza and Louvre agreements, which were targeted at reducing volatility. A series of papers finds results suggesting that interventions can smooth volatility.[11] Still, the discussion is far from reaching a consensus, with numerous recent studies refuting the conclusions of earlier ones. Sarno and Taylor and Ramaswamy and Samiei provide extensive reviews to this still-open debate.[12]

The disparity of results can be attributed, in part, to the presence of two empirical problems. The first is the lack of data. This problem stems from

10. Jurgensen (1983).
11. Domínguez and Frankel (1993, 1994), among others.
12. Sarno and Taylor (2001); Ramaswamy and Samiei (2000).

the reluctance of central banks to publish official intervention information, which makes the task of gathering statistics time-consuming and inefficient. The second is, as mentioned, the simultaneity bias in the estimation of the effect of spot interventions on the exchange rate.

Regarding the first problem, public information on interventions is very scarce worldwide. Central banks normally do not make public announcements of their interventions, let alone disclose the amounts involved. Even when present, disclosures are few and infrequent in comparison with the time span in which one expects the market to adjust to intervention—often days or even hours. This deficiency has forced researchers to build indirect intervention series, resorting to sources such as media news, surveys, and movements in international reserves. Since these proxies are far from perfect, the intervention series built on them may not be adequate for estimating the true effects of exchange rate interventions.

Even when information exists, estimates derived from the impact of exchange rate interventions can be misleading if they do not take into account the simultaneous nature of the exchange rate determination process and of intervention decisions, which are typically discretional and made on a daily or hourly basis.[13] If the analyst does not control for this simultaneous process, the results obtained may be biased. In particular, the spot intervention coefficient may be biased upwards, and the effect—although significant and negative in the true model—may appear to be insignificant or even positive.

Exchange Rate Interventions in Practice: Chile's Experience, 1998–2003

The number of countries leaning toward flexible exchange rate arrangements has grown in recent years.[14] Countries with truly clean floating regimes, however, are few. Almost all countries that are classified as free floaters by the International Monetary Fund (IMF), including Chile, either intervene in the market with some frequency or explicitly reserve the right

13. In general, exchange rate interventions occur whenever the exchange rate moves in the opposite direction of the effect that is pursued by the central bank's decision. The central bank is more likely to sell foreign currency when the exchange rate is rising—to bring it down—than when it is already falling. This may lead one to equate exchange rate increases with the sale of foreign currency, when causality goes in the opposite direction.

14. Hochreichter, Schmidt-Hebbel, and Winckler (2002).

to do so. Table 1 provides some examples of intervention practices and motivations in countries with floating regimes. New Zealand is the world's clearest example of a clean floating regime, with no interventions in the last eighteen years. Countries that are usually taken as the epitome of free floating, such as Japan or the United States, have intervened in the market frequently, although recent trends point toward less frequent, yet bigger interventions than in the past.[15] Other countries, such as Colombia, operate with predetermined intervention rules linked to the evolution of exchange rate volatility, as suggested by Williamson.[16]

Interventions typically do not target specific values, but rather are motivated by the desire to smooth excessive short-run fluctuations or resist short-run trends (so-called leaning against the wind) that could be driving the exchange rate away from its fundamentals. Motives such as optimal portfolio and reserves management are also mentioned. In most countries, the central bank is the institution conducting intervention, either autonomously or in accord with the government.

Chile's Intervention Experience, 1998–2003

Interventions in Chile are decided and conducted autonomously by the Central Bank, which is fully independent from the government. The central government has the capacity to intervene if it decides to strategically manage the resources obtained from its revenues (mainly flows derived from copper sales).[17] No information exists regarding this form of intervention, however, so we excluded it from the paper. Moreover, government sales should be ineffective through the signaling channel, as the government has no influence over monetary policy decisions.

Chile has resorted to intervention activities less frequently than other central banks (see table 2). The median intervention frequency among the central banks surveyed by Neely was 25 percent of trading days throughout the 1990s.[18] The Central Bank of Chile intervened in the market on

15. Ito (2002); Taylor (2004). Calvo and Reinhart (2002) use the Japanese and U.S. regimes as the benchmark for analyzing whether developing countries behave as free floaters.

16. Williamson (1998).

17. In particular, copper sales made through the state company, CODELCO.

18. Neely (2001).

TABLE 1. Characteristics of Intervention Practices in Selected Countries with Floating Exchange Rate Regimes

Country	*Description of intervention practices*
Brazil	The float is explicitly dirty, either to support the inflation rate or under exceptional circumstances. The Central Bank tries to intervene with high transparency.
Canada	Until 1998, a mechanical rule for intervention was in place, together with the discretional faculty to intervene at any time. The rule was abandoned in 1998, after it was concluded that interventions were unable to reduce volatility. The discretional faculty remains, but it has not been used in recent years.
Colombia	Clear rules for intervention were defined in 1999, depending both on the presence of violent exchange rate fluctuations and on the existence of high exchange rate volatility.
European Monetary Union	Interventions are conducted subject to the price stability objective.
Indonesia	Interventions are undertaken to control the monetary base, reduce depreciation pressures, and diminish exchange rate volatility.
Japan	The Central Bank intervenes to execute decisions from the Ministry of Finance. A special fund for intervention is available. Interventions are sometimes coordinated with other central banks or conducted in foreign markets. Interventions are triggered by the presence of excessive volatility, and the effects of the intervention and the market's response are monitored. The Central Bank plans to publish monthly information, but it has not done so yet.
Mexico	The Bank of Mexico has an intervention rule consisting of daily auctions of U.S.$200 million among commercial banks, with a minimum price that equals 1.02 times the exchange rate officially published by the Central Bank of Mexico each day. The Central Bank believes these schemes reduce exchange rate volatility, while still allowing the market to freely determine the exchange rate's equilibrium level. The Central Bank can also sell additional resources, over and above those included in the auction.
New Zealand	The exchange rate has floated freely, without intervention, since 1985. However, the Central Bank has the faculty to intervene, at least nominally.
Peru	Intervention is conducted in scenarios with high exchange rate volatility, to attain higher confidence in the exchange rate market.
Poland	No interventions since 2000.
Sweden	The Central Bank's board decides whether to intervene to fulfill different objectives, in particular portfolio balance and economic objectives that do not threaten the inflation target. Clear rules exist to ensure transparency, but some space for surprises remains. Intervention periods cannot exceed the period between two policy meetings.
Switzerland	Interventions are conducted only under exceptional circumstances, and they must be announced ex ante.
United Kingdom	Sporadic interventions have occurred since the adoption of the float in 1992. Decisions are taken jointly by the Bank of England and the central government; both entities provide funding. Intervention must be coherent with monetary objectives. Monthly information is provided.
United States	The Department of the Treasury or the Federal Reserve can make intervention decisions. The Treasury's opinion has primacy. The Federal Reserve Bank of New York conducts interventions. Public information is published only on a quarterly basis. Motives to intervene are various: to support the exchange rate's trend; to calm disordered markets; to manage foreign reserves; and to support intervention policies conducted by foreign central banks.

Source: Authors' compilation, based on central banks' websites and reports.

TABLE 2. Main Features of Spot Interventions in Selected Countries

Country	Starting date	Ending date	Daily sales (millions of US$)		Share of market days with intervention (percent)
			Minimum	Maximum	
Australia	12/13/83	7/30/99	−436	932	42.3
Chile	8/16/01	12/31/01	0	129	15.0
Germany	7/83	12/98	−800	833	12.5
Switzerland	3/86	12/99	−150	545	3.9
United States	7/83	12/98	−950	951	5.3

Source: Kearns and Rigobon (2002); authors' calculations.

only 15 percent of the trading days between August and December 2001, when an explicit intervention regime was announced within the context of the floating scheme.

The intervention episodes analyzed herein occurred in three periods. In all of them, the Central Bank's actions were related to sales of dollar-denominated bonds or dollars. Interventions involving dollar purchases, which were very frequent until 1997, are not included because no daily data exist prior to 1998. In the first period, from January 1998 to September 1999, the presence of the floating band implied an explicit exchange rate target.[19] The Central Bank of Chile had (and frequently used) the authority to intervene in the foreign exchange market at its discretion, even if the exchange rate was far from the band's boundaries. In fact, intramarginal interventions within the band were frequent in the 1990s. The 1998–99 period was also characterized by successive episodes of speculative attacks against the peso, triggered by the international turmoil associated with the Asian crisis and its repercussions.

The second period began on 16 August 2001, when the Central Bank announced that from that date until the end of the year it could intervene in the foreign exchange market, which had been operating under a free float since September 1999. Resources available for intervention were announced to be a maximum of U.S.$2 billion in open market operations and another U.S.$2 billion in dollar-denominated instruments.[20]

19. The last intervention of this period occurred in early 1999, with no further operations until 2001. We extend the first period to September 1999, however, since the policy regime—and thus the possibility of intervention—remained in place until the band was abandoned.

20. Actual interventions through open market operations occurred over a shorter time interval: the last one took place in late October. In its August announcement, however, the

The third period is similar in nature to the second one. On 10 October 2002, the Central Bank announced that, over a period of four months, it could intervene in the foreign exchange market for maximum amounts of U.S.$2 billion in open market operations and another U.S.$2 billion in dollar-denominated notes. In this case, however, the announcement did not translate into actual interventions in the spot market.

This paper studies the effect on the exchange rate of the various foreign exchange intervention policies applied since 1998. To that end, we examine the impact on the exchange rate of spot foreign currency sales by the Central Bank and the placement of dollar-denominated notes at different maturities (*bonos del Banco Central en dólares*, or BCDs). We distinguish between these two types of instruments because their impact on the currency's value may differ, given their different characteristics.[21]

However, analyzing only the direct effect of individual interventions might be misleading, because the Central Bank's actions disclosed information to the market regarding its future policies—to different extents depending on the type of instrument and the period studied. The market should have adjusted immediately to the new information, before actual interventions took place. This is particularly true for BCDs, for which the exact amount of papers to be sold, together with the specific dates in which the sales will be made, is announced at the beginning of each reserve requirement period (typically on the eighth day of each month).

Spot sales are somewhat different. In 1998, no ex ante information existed on the amounts or timing of such sales. The market only knew that, given the foreign exchange regime, the space for potential interventions was open at any given time, and that the maximum amount of resources that could be used was equivalent to the stock of international reserves held by the Central Bank. By 2001, information became more accurate. The announcement implied an explicit change in the regime, where the

Central Bank reserved the right to intervene in the market until 31 December 2001, so the exception regime within the floating scheme remained in place until that date. Interventions with Central Bank notes occurred throughout the whole period (and began a couple of months earlier).

21. In terms of portfolio, foreign currency sales indirectly provide liquidity to investors whose needs or relevant horizons are short-term, but the notes can provide a source of hedging for agents with longer horizons. In terms of the signal, the two instruments may deliver different information on potential future policy changes and on the timing of their occurrence.

clean float policy applied between 1999 and July 2001 was publicly suspended for a definite period of time. The announcement set an upper bound for the amount of resources to be used, which is viewed as more precise than the implicit limit in 1998–99—namely, the total value of reserves. It is thus reasonable to assume that when the Central Bank announced its intervention policy, the market generated expectations on the actual amount of resources to be injected into the market. As mentioned earlier, successive interventions (combined with the passage of time and new macroeconomic information) would validate (or adjust) original expectations, as well as the initial effect associated with them.[22] In 2002–03, for example, market expectations were revised downwards when the market became aware that the expected spot sales had not taken place and that the Central Bank would not use its power to sell foreign currency.

FEATURES OF THE INTERVENTION PERIODS. Determining the endpoint of the first period is easy: the abandonment of the band in September 1999 and its replacement with the floating regime currently in place. The starting point, however, is conditional on information availability, since no daily data on intervention exist prior to 1998. The available data correspond to a period when the Chilean economy, in general, and the foreign exchange market, in particular, suffered the consequences of a series of adverse international events.

The speculative attacks on the peso in January and June of 1998 were no surprise, given that the terms of trade fell more than 10 percent between 1997 and 1998, sovereign spreads increased from under 100 basis points in 1997 to over 400 basis points in August of 1998, and the current account deficit was dangerously high and growing in the context of a severe contraction of capital inflows. Although the attacks never really jeopardized the band (the exchange rate remained far from the upper bound, generally below the middle), authorities feared that a sharp devaluation might affect annual inflation and threaten the long-lasting inflation reduction strategy implemented since the early 1990s. Successive interventions to safeguard the peso were therefore complemented with monetary policy actions and several variations in the band definition and width. When speculative pres-

22. Strictly speaking, relevant information comes to the market not only through the Central Bank's official policy announcements, but also via its authorities' speeches and public statements.

sures diminished around October, the band was widened, and interventions became rare until the float was adopted a year later.

Spot market interventions in the first period occurred between January 1998 and March 1999, primarily concentrated in January, June, July, and September 1998. Sales amounted to a combined total of U.S.$4.285 billion and materialized within forty-three days of intervention, or 10 percent of the trading days in the period.[23] The average monthly amount of foreign currency sold in the market during these episodes was U.S.$109 million in 1998 and U.S.$39 million in 1999. The amounts involved varied widely, from frequent small interventions worth U.S.$5 million to two large operations of over U.S.$350 million (in January and June of 1998).

BCD sales were concentrated between July 1998 and April 1999, totaling U.S.$1.44 billion. All occurred over 60 days, or 14 percent of the period's working days. With regard to the exchange rate, the peso devaluated by 16 percent against the dollar. The maximum devaluation in one day was 2.5 percent (in January 1998), with a peak appreciation of 1.4 percent (also in January 1998).

The second period began after the band was abandoned in September 1999 and the exchange rate was allowed to float freely, consistent with the long-term inflation target. The Central Bank reserved its right to participate in the foreign exchange market on exceptional occasions, however, promising to explain to the general public its reasons for doing so. Such an occasion came in August 2001, after the severe turmoil in the region caused by the economic situation in Argentina induced a currency depreciation of nearly 20 percent in the first half of the year. The Central Bank's fear of an exchange rate misalignment—and the resulting cost in terms of relative prices and inefficient resource allocation—resulted in the announcement of a limited intervention period.[24] Specifically, the Central Bank communicated on 16 August 2001 that spot market interventions could occur through 31 December 2001 and would be restricted to a maximum of U.S.$2 billion. Additional BCD sales for a similar amount were

23. The amount is equivalent to 25 percent of international reserves existing in December 1997.

24. The Central Bank's Monetary Policy Report of January 2003 explains that the motive behind the interventions was to prevent the adverse consequences of a possible overreaction. Recognizing that, a priori, it is not feasible to establish precisely whether a foreign exchange movement is excessive, the authorities did not intend to defend a specific exchange rate, but "to limit the chances of overreaction without hindering an efficient adjustment via prices."

also announced (some BCD sales had already been announced in the preceding months).

Actual spot market interventions were concentrated in September and October and totaled U.S.$803 million—less than half the maximum announced and nearly 5 percent of the total stock of international reserves. The amounts traded in the fifteen interventions (15 percent of working days) were substantially smaller than in the interventions of the first period, with an average of U.S.$54 million and a peak of U.S.$129 million, less than half the maximum amount observed in 1998.

The sale of BCDs, meanwhile, was distributed more evenly over the second half of the year. Sales totaled U.S.$3.04 billion, including the BCDs that were part of the regular program. BCD sales were more frequent than interventions in the spot market and even more frequent than sales of BCDs in 1998; they covered 37 percent of working days in the period.

During the intervention period, the exchange rate appreciated 3.9 percent (partly reversing the depreciation observed before August), although it accumulated a devaluation of nearly 5 percent in September. The maximum daily devaluation was 2.8 percent (in September) and the maximum appreciation in one day was 1.8 percent (in October).

The final period under analysis began on 10 October 2002, when the Central Bank announced a period of interventions very much like that of 2001, scheduled to end on 10 February 2003. The announcement came in response to a complex global scenario that included a sharp increase in the Brazilian country risk rate. This international context caused the peso-dollar exchange rate to depreciate 7 percent in one month, showing an ever-increasing trend.

Contrary to the previous experience, the authorities did not use the available foreign currency reserves for spot intervention, and no operations of that type were carried out. The Central Bank did undertake BCD sales, however, valued at U.S.$500 million dollars in each of the first two months (October and November). Subsequently, the authorities considered that a milder intervention would suffice, and the Central Bank sold U.S.$250 million in each of the following months (December and January).

The exchange rate first appreciated by 8.8 percent through mid-December and then relapsed in the following months. Total appreciation for the period was 2.1 percent, which partly reversed the depreciation leading up

to the intervention. The biggest depreciation in one day was 1.3 percent, and an appreciation of 2.3 percent occurred the day after the intervention announcement.

A PRELIMINARY EVALUATION OF FOREIGN EXCHANGE INTERVENTIONS. The three periods under study differ in the amounts of foreign currency involved. While the average intervention of 1998–99 amounted to nearly 10 percent of the average transactions in the spot market over the period (with the largest interventions exceeding 30 percent), spot interventions in 2001 averaged less than 5 percent of the daily volumes traded in the market, and no spot market interventions occurred in 2002–03. This could suggest that the portfolio channel—if it exists—might have been stronger in 1998–99 than in 2001–03.

What about the monetary policy signal given by interventions? In 1998–99, the transparency of the interventions was limited, because neither the exact date nor the amounts involved were disclosed to the market. Intervention was discretional, and there was no a priori limit to the resources that could be used.[25] Information on interventions could only be measured by proxy, on the basis of the biweekly publications on the movements of international reserves, although that figure also included other portfolio adjustments not associated with intervention activities.

The 2001 interventions were more transparent. The Central Bank explicitly declared the total amount of resources available for intervention, the time span over which such interventions might occur, and the rationale for such a policy action. Reports on specific intervention episodes were only partial, however: the Central Bank announced that it had intervened, but it did not disclose the amounts involved in each operation. Such information could only be derived every two weeks from statistics on reserve movements, which include an explicit entry for intervention amounts.[26] In 2002, daily announcements obviously never happened. In our previous work, we present some preliminary evidence—using press information—on market perceptions regarding interventions in the three different periods.[27] If the signaling channel is correct, actual intervention activities are not relevant; the key factor is what the market believes to be the signal provided by the Central Bank. As expected, the evidence shows that market

25. The obvious limit on the sale of foreign currency was the stock of international reserves.

26. In other words, intervention was fully public on a bimonthly frequency.

27. Tapia and Tokman (2003).

perceptions were much more precise with regard to actual interventions in 2001 than in 1998–99, suggesting that the signal channel was weaker in 1998–99 than in 2001. Even so, more or less clarity regarding individual signals may be unimportant in the presence of an intervention announcement, which can carry a large informational content that is greater than the marginal contribution of individual interventions.

Time-Series Estimates

The main potential pitfall of traditional empirical exercises for analyzing the impact of individual exchange rate interventions in the spot market is the existence of a simultaneous process between exchange rate determination and intervention decisions. The bias caused by the endogeneity of interventions could explain the fact that most studies find the estimated coefficients of the impact of intervention to be statistically equal to zero or to have the wrong (positive) sign.[28] Simultaneity is not an issue in infinitesimal units of time (the intervention responds necessarily to a specific exchange rate variation that occurs before it, and causes an effect that materializes after), but it probably exists for the frequency of the available data.

The magnitude of the bias can be quantified by independently estimating equations for interventions and the exchange rate.[29] For the case of Chile, the existence of simultaneous equations implies that the estimated intervention parameter lies within bounds whose width forbids any reasonable inference about the parameter's true value (the upper bound is more than a hundred times the lower bound!).

Thus, the potential bias is clearly a relevant problem. The literature addresses this problem in two ways. The simplest (and rather rough) method is to use lagged interventions.[30] Although this eliminates the possible simultaneity (in that the past intervention is necessarily exogenous to the contemporaneous exchange rate), it can distort the estimated effect of the intervention. The estimated functional form assumes that the exchange rate responds only to past information, ignoring the contemporaneous

28. Sarno and Taylor (2001).
29. For further description, see Kearns and Rigobon (2002).
30. See, for example, Baillie and Osterberg (1997); Lewis (1995).

effect. If markets are efficient and interventions are information, however, then only the contemporaneous effect should exist. The second approach is to resort to more sophisticated econometric methods that allow the estimation of the system of equations of interest, either simultaneously or in two stages with instrumental variables.[31]

We use a two-stage instrumental variable model to estimate the impact of daily interventions between 1998 and 2003. We complement the results with intraday data, which are only available for the 2001 intervention episodes. These data allow us to estimate ordinary least squares (OLS) equations for the second period, since the use of lagged interventions to avoid simultaneity is not a crucial distortion in the face of such short time intervals.

Description of the Variables Used

The sample used for the first estimation covers January 1998 to February 2003, with daily data defined in five-day weeks, including holidays. The dependent variable is the daily movement of the logarithm of the interbank market exchange rate at the market's closing time.[32]

We built a number of variables to measure the Central Bank's participation in the foreign exchange market. The most commonly used in the literature is the daily amount of foreign currency sold in the spot market, in millions of dollars. We built a similar variable with the aggregate stock of papers sold on a specific day (the amounts of instruments with different maturities are added together).

The paper's main contribution is to recognize the existence of the third instrument through which interventions affect the exchange rate market. Announcements made by the monetary authorities, rather than the individual interventions typically studied in the literature, were the main instrument of intervention policy affecting the exchange rate in Chile in 2001 and 2002. To check this possibility, we included variables reflecting public announcements. One dummy for 16 August 2001 and another for 10 October 2002 (signaling the announcement of the beginning of the

31. Mundaca (2001); Kearns and Rigobon (2002).

32. This is not the only possible definition of the exchange rate that we could have chosen for the whole sample: other variables, such as the average exchange rate or the opening exchange rate, were also good candidates. Although results are not reported for space reasons, the main conclusions shown below are the same for the alternative definitions that we estimated.

intervention periods),[33] plus a variable for the monthly announcements of auctions (in millions of U.S. dollars, for the total amount of instruments being tendered), serve that purpose.

Why should these variables be important? After receiving an announcement regarding the two recent intervention periods, the market knew that the Central Bank was prepared to place a certain amount of foreign currency in the market, which changed—albeit marginally—the characteristics of the floating regime. This anticipation ought to translate into an exchange rate adjustment before interventions actually take place. This does not mean that the only effect should occur at the moment of the announcement. First, the information disclosed by the Central Bank did not identify the specific intervention amounts, but rather set a ceiling for the resources that could be used. Even if the announcement were credible, the amount of resources that the market expected the Central Bank to employ could have ranged between slightly more than zero and the announced upper bound. Actual spot and BCD dollar sales remained uncertain, so the occurrence of sales should have caused the market to adjust its intervention expectations (in either direction, which cannot be defined in advance). For example, if a central bank performs only small, infrequent interventions, the market may well revise downward its expected total amount sold, which was generated when the market expected large interventions. If such is the case, a specific sale of dollars may not cause an appreciation of the exchange rate, but rather a depreciation, when the level of equilibrium derived from expectations is found to be wrong. In the 2002–03 period, actual intervention (zero in the spot market) was probably below expectations, which may have weakened or reversed the initial appreciation generated by the announcement. Second, given the logic of the signaling channel, the initial effect on the exchange rate may be reversed if interventions are not validated by a monetary policy action or if credibility is not absolute on the inflation rate commitment.[34]

These elements, which are not considered in previous intervention studies, call for the incorporation of variables in addition to intervention and announcement. The dummy variable for the announcement corresponds to a single effect on the exchange rate's level. However, intervention (or the explicit threat of it) may generate an effect on the exchange rate's trend.

33. The announcement was made on the afternoon of 16 August, when the market had already closed. The same happened in 2002.

34. Intervention per se has no effect on that mechanism.

This could reflect the smoothing of the abnormal trend that triggered the intervention or, in a world where the exchange rate is always in equilibrium, changes in the market's evaluation of the diverse shocks and actions taken.[35] This effect will be felt over a longer horizon than the effect of the announcement, and it will not be properly captured by any of the variables defined so far. We therefore created a dummy variable for the intervention period in 2001 (August to December 2001) and another for the 2002–03 period (October 2002 to February 2003). Any value other than zero means that a particular trend is associated with the exchange rate in that period. To capture the market's updating of its intervention expectations during the participation period, these dummies are multiplied by a time trend, suggesting that the effect of the intervention period can change (linearly) as the period comes to an end.

We generated an analogous dummy for the 1998–99 intervention period. This period had no explicit intervention announcements, and the nature of the prevailing regime allowed them to happen at any time, with no other upper bound than the total amount of available reserves.

A relevant issue regarding announcements is that, unlike daily intervention decisions, they are not endogenous to daily exchange rate variations. While daily interventions occurred in a series of intraday operations decided by analyzing the intraday evolution of the exchange rate, the announcements were the result of long, exhaustive discussions among the members of the Central Bank Board and technical staff that were conducted over several days. Additionally, announcements were made after market transactions had ceased. Even if the announcement were decided based on the evolution of the exchange rate on the same day of the decision, its effect was necessarily seen the next day, when the market reopened. This time ordering necessarily avoids any risk of simultaneity.

One last variable, built from the Central Bank's intervention data, is the excess demand for BCDs, measured as the difference between the demand for papers on the day of the auction and the available supply. This variable, together with the set of variables defined next, controls for market conditions.

35. In the absence of intervention, the exchange rate's equilibrium may be shifting along with the evolution of its relevant fundamentals. The threat of intervention, however, might soften this movement—not because the trend itself has changed, but because the market is aware that a new fundamental variable (intervention, or the threat of it) has triggered a new equilibrium trend.

With regard to control variables, the lack of a formal model for the exchange rate process leads us to take an approximation that incorporates the maximum number of variables that both the theoretical and the empirical literature have suggested as potentially important and that are available on a daily frequency. In particular, the set of controls includes the following variables: the differential between domestic and U.S. short-term interest rates; the sovereign risk of Argentina, Brazil, and emerging economies; the copper price; the oil price; and the price of the Brazilian currency in dollars. All these variables, except the interest rate differential, are expressed in logarithmic differences. The variables for spreads are introduced to evaluate possible changes in agents' risk perceptions, leading to subsequent portfolio adjustments. The interest rate differential controls for the arbitrage condition given by the uncovered interest rate parity. The world prices of copper and oil serve as a proxy for the terms of trade, with a potential impact on income.

We also included dummy variables to control for other relevant episodes, such as changes in the monetary policy rate or in the defined exchange rate band. The 2001 period incorporates a dummy for 11 September, when the attacks in the United States had a temporary impact on the exchange rate through the anomalous interrupted functioning of financial markets.

We performed several robustness tests, involving different specifications. Results are qualitatively and quantitatively similar, and they are not presented for the sake of brevity.

Finally, the Central Bank's spot market intervention decision is modeled as dependent on the accumulated percentage variation of the exchange rate in five days, the stock of international reserves, and past interventions.

Estimation and Results

We start the procedure by identifying a valid instrument to account for the endogeneity of intervention decisions to exchange rate variations. This involves estimating, with OLS, an intervention reaction function that provides a reasonable description of the individual spot market interventions.[36] The explanatory variables included are the stock of international

36. We check for white noise errors and good predictive power.

TABLE 3. Spot Intervention Reaction Function, January 1998 to February 2003[a]

Explanatory variable	*Coefficient*	*Newey-West standard error*
Constant	–0.58	0.35
Five-day cumulated exchange rate variation	2.38*	1.34
Intervention (–1)	0.39*	0.07
Band period	5.95*	1.77
Intervention period 2001	5.19	2.14
Intervention period 2002	0.61*	0.66
Summary statistic		
Adjusted R^2	0.21	

Source: Authors' estimates based on Central Bank of Chile information.

* Statistically significant at the 10 percent level.

a. The dependent variable is daily spot interventions (in millions of U.S. dollars).The regressions are estimated using OLS and include macroeconomic variables.

reserves, the five-day cumulative exchange rate variation, lagged interventions, and other macroeconomic controls. Table 3 presents the estimated equation. Interventions are highly inertial. Cumulative exchange rate variations, identified as a potential instrument from an economic perspective, appear to be a statistically significant determinant of daily interventions.

To check the validity of the proposed instrument, we conduct an LM-type test by computing the residuals of the exchange rate equation that contains the predicted spot interventions (from the reaction function regression) and all the other controls discussed and then regressing it against all the controls of the exchange rate equation, the instrument, and the predicted spot interventions. The test does not reject the null hypothesis of orthogonality of the instrument, and thus we use it in the subsequent estimations. The results for the exchange rate equation using the instrumented interventions are presented in table 4.

For clearer presentation, we separated the variables into different blocks within the table. Control variables, including macroeconomic variables and monetary policy dummies, are not presented for brevity, although almost all of them had the expected signs. The first block includes dummies for the three different intervention periods, in addition to a constant. The second block presents variables associated with the intervention announcements made in 2001 and 2002. As discussed earlier, announcements should have an instantaneous impact on the exchange rate even if no actual intervention activities are pursued, because they deliver

TABLE 4. Daily Closing Exchange Rate Variation, January 1998 to February 2003[a]

Variables	*Coefficient*	t *statistic*
Constant	0.0003*	2.16
Trend effects		
1998–99 period	–0.0001	–0.32
Intervention period 2001	–0.0019*	–1.67
Intervention period 2002	–0.0029*	–2.23
Intervention period 2001*time	–6.3E–05	–0.40
Intervention period 2002*time	5.3E–05*	2.92
Announcement effects		
Announcement 2001 (–1)	–0.0154*	–14.20
Announcement 2001 (–2)	–0.0066*	–6.19
Announcement 2001 (–3)	–0.0062*	–5.87
Announcement 2002 (–1)	–0.0155*	–7.47
Announcement 2002 (–2)	0.0073*	5.57
Announcement 2002 (–4)	0.0034*	2.50
Intervention variables 1998–99 (exchange rate band period)		
Band period*Intervention	–2.4E–05*	–2.18
Band period*BCD	–4.8E–05*	–2.96
Band period*BCD announcement	–2.4E–07	–0.04
Intervention variables 2001 (first intervention period)		
Intervention period 2001*Intervention	3.0E–05	0.51
Intervention period 2001*BCD	–1.3E–05	–0.59
Intervention period 2001*BCD announcement	3.88E–05	1.25
Intervention variables 2002 (second intervention period)		
Intervention period 2002*BCD	–3.3E–05	–1.43
Intervention period 2002*BCD announcement	–1.0E–05*	–1.93
Summary statistic		
Adjusted R^2	0.21	

Source: Authors' estimates, based on Central Bank of Chile information.

* Statistically significant at the 10 percent level.

a. The dependent variable is the daily closing exchange rate variation. The regressions are estimated using two-stage OLS with Newey-West errors. All regressions control for macroeconomic and policy change variables. All variables, except intervention, BCD, BCD announcement, excess demand BCD, interest rate differential and time, are in logarithmic differences.

information to the market regarding (uncertain) future Central Bank actions.

Blocks three, four, and five show the estimated coefficients of the interactive intervention variables defined for each of the three intervention periods under analysis: 1998–99, 2001 (16 August to 31 December), and 2002–03 (10 October 2002 to 10 February 2003). Interactive variables allow the impact of intervention to differ among regimes. If the frame-

works under which interventions were conducted in different periods have implications for their impact on the exchange rate, then estimating a single coefficient may be misleading. A negligible, insignificant overall effect of individual interventions may be an average of significant coefficients of different magnitudes. Differentiated effects of interventions are expected given the different characteristics of the policy actions in each period (frequency, transparency, and so forth). Moreover, the impact of intervention may differ among the two episodes within the floating regime, as market expectations or macroeconomic conditions may have varied.

The results indicate that individual spot interventions had a significant negative effect in 1998, thereby appreciating the peso. The size of the coefficient implies that a sale of U.S.$500 million would have been required to appreciate the exchange rate by 1 percent. For 2001, when interventions were conducted after the formal policy announcement, the coefficient is not significantly different from zero. The same applies to bond sales: the coefficient is significant and negative in 1998, but insignificant in 2001 and 2002.

This does not imply that interventions had no effect in 2001 or 2002. The public announcement of an intervention period had a large, significant effect, with a cumulative appreciation of 2.7 percent and 0.5 percent in 2001 and 2002, respectively.[37] This suggests that the announcement was deemed credible by the market in both years, causing an adjustment in expectations and, subsequently, in the exchange rate. Based on the scale of the impact of individual interventions found for 1998, the peso appreciation associated with the 2001 announcement is equivalent to a sale of U.S.$1.5 billion. This seems to be a reasonable value for the market's expectations regarding future interventions, since it lies below the U.S.$2.0 billion ceiling that was announced on that date. The impact was smaller in 2002, suggesting that the likelihood of future interventions was perceived to be lower by market participants.

Dummy variables measuring a possible change in the exchange rate's trend during the intervention periods are significant for 2001 and 2002. The coefficients suggest that the intervention periods were related to appreciation trends of around 0.18 percent and 0.28 percent daily, respectively.

37. The existence of significant lags in the response to intervention announcements suggests that the market adjusts slowly.

An additional element is the possible existence of linear time trends in the intervention periods' dummies, capturing changes in the trend effect of intervention periods in time. A positive, significant coefficient is, in fact, estimated for the 2002 intervention period, which suggests that the shift toward appreciation observed at the beginning of the period becomes weaker as time advances. This result seems reasonable: when no actual spot interventions took place in 2002, agents (who had adjusted the exchange rate in expectation of some positive value for spot interventions) revised their expectations and reversed the currency's initial appreciation trend.

In summary, our results suggest that the impact of individual interventions was only significant in 1998, when the Central Bank made no formal announcements regarding interventions. The policy framework changed in 2001 and 2002. We find a significant effect of relevant economic magnitude for the second and third intervention periods, in terms of both level and trend. Both periods were characterized by explicit announcements on the conduction of intervention activities. The diminishing effect for 2002 suggests that credibility fell when the announcement was not validated with actual spot interventions.

A possible critique of the empirical approach taken here is that the definition of dummies is arbitrary. Strictly speaking, the 2001 intervention dummy is contemporary with the intervention period, but it is not necessarily associated with it because it could also reflect omitted developments occurring in the same period. This poses two potential problems. First, what is labeled intervention could actually be an unidentified, omitted process that is driving the exchange rate. Second, the period chosen for the dummy might not be robust in itself; the results may change if the time span is defined differently. With regard to the first problem, our use of a wide group of controls (basically, the whole set of relevant macroeconomic and financial variables available at a daily frequency, plus dummies controlling for policy changes) makes the presence of an omitted variable unlikely. Regarding the second critique, an earlier version of this paper, which only included data for interventions through 2001, finds essentially identical results. In fact, the results found when one includes the 2002 data are consistent with the paper's hypothesis on the transmission mechanism. This reinforces our confidence in the estimated results and in our interpretation of them.

Intraday Data

To check the robustness of the main results presented above, we performed OLS estimations using intraday data from transactions conducted at Santiago's online stock market.[38] This strategy has certain drawbacks. First, information on intraday exchange rate variations is only available for the fourteen intervention days in 2001. Second, the data are not presented at regular time intervals, but at every tick, or transaction time. These transactions obviously differ in number and frequency within and between days. Third, none of the macroeconomic variables used as controls in the previous estimation are available at this frequency.

These limitations led us to estimate a separate OLS regression for each of the fourteen days for which data are available, including only exchange rate variations and interventions (and lags) as variables. Three time spans are used for the definition of both variables. First, exchange rate variations are defined as the change between private transactions, regardless of the time span between them. Price quotes for intervention operations are excluded, such that we measure the effect of intervention as the change in the exchange rate between the transaction conducted immediately before and immediately after the intervention. In this case, interventions are necessarily exogenous to the exchange rate. The second approach defines the exchange rate variation in ten-minute spans, regardless of the number of transactions occurring within that period.[39] The intervention variable is defined as the accumulated sum of interventions occurring within the time span. Interventions could thus be endogenous, in contrast with the former case. As discussed before, however, no potential instruments are available at this frequency. The third approach is the same as the former, but with twenty-minute windows. For all cases, the variables are defined for transactions occurring between 9:00 A.M. and 1:00 P.M.; the closing time is extended for days on which late interventions occurred.

The results are presented in tables 5 and 6. An analysis of transactions uncovers small, short-lived effects on eleven of the fourteen days. On the remaining three days, net effects are significantly positive, although no

38. The Bolsa Electrónica de Chile, at www.bolchile.cl.

39. Defining ten-minute spans was not always possible, as no transactions occurred precisely with that difference. In those cases, we took the transactions that lie closest to the selected span.

TABLE 5. Intraday Exchange Rate Variations between Transactions[a]

Day	*Intervention*	*One lag*	*Two lags*	*Three lags*	*Four lags*	*Five lags*	*Net effect*
1	−1.4E−04** (−2.659)						−1.41E−04
2	−2.3E−04** (−3.611)						−2.36E−04
3	−1.9E−04** (−2.366)		4.52E−05** (2.400)				−1.53E−04
4	−6.5E−05 (−1.254)	−5.5E−05** (−2.637)					−5.57E−05
5	−1.7E−04** (−3.227)	1.06E−04** (3.707)					−5.90E−05
6	−5.2E−04** (−7.714)	1.52E−04** (5.354)					−3.63E−04
7	−7.9E−05** (−2.628)			4.6E−05** (3.920)	2.6E−05** (2.558)		−7.60E−06
8	−8.3E−05** (−2.594)						−8.32E−05
9	−2.8E−05** (−3.171)	1.32E−05** (3.004)	1.59E−05** (2.747)				8.00E−07
10	−2.1E−05 (−1.625)					−5.2E−05** (−2.340)	−5.24E−06
11	−2.5E−05** (−110.5)	2.10E−05** (20.64)					−4.50E−06
12	−4.4E−05** (−5.178)		2.02E−05** (2.304)			1.99E−05** (2.267)	−4.20E−06
13	2.53E−05 (−1.744)	5.66E−05** (3.921)			3.3E−05** (6.93)		8.94E−05
14	−1.98E−06 (−0.287902)				1.07E−05** (2.72)		1.07E−05

Source: Authors' estimates, based on information from the Central Bank of Chile.

** Statistically significant at the 5 percent level.

a. The regressions are OLS estimations using intraday data from transactions conducted at Santiago's online stock market on the fourteen intervention days in 2001. Exchange rate variations are defined as the change between private transactions, regardless of the time span between them. Price quotes for intervention operations are excluded, such that we measure the effect of intervention as the change in the exchange rate between the transaction conducted immediately before and immediately after the intervention. Lags were only included when significant. Newey-West standard errors are in parentheses.

potential simultaneity problem exists. The effects of intervention appear to be smaller when we consider ten-minute time spans (which, in almost all cases, represent a larger horizon than the span between two transactions). They are only significantly negative in six of the fourteen cases and significantly positive on two additional days. Finally, the effects become even smaller with twenty-minute windows: they are significantly negative on scarcely four days and significantly positive also on four days. Although these results should be read with some caution owing to the lack

TABLE 6. Intraday Exchange Rate, Ten- and Twenty-Minute Variations[a]

	Ten-minute intervals			*Twenty-minute intervals*	
Day	*Intervention*	*One lag*	*Net effect*	*Intervention*	*Net effect*
1	−6.4E−04** (−2.00)	−7.9E−04** (−3.79)	−1.44E−03	−1.4E−03** (−2.54)	−1.41E−03
2	8.75E−06 (0.16)	1.58E−04** (2.53)	1.58E−04	1.79E−04** (3.40)	1.79E−04
3	7.29E−05 (1.36)		0	−1.80E−04 (−1.84)	0
4	−3.17E−05 (−0.61)		0	4.66E−05 (1.66)	0
5	−6.07E−05 (−0.60)		0	2.36E−05 (0.31)	0
6	−5.5E−04** (−3.31)	6.01E−04** (2.65)	4.80E−05	−1.18E−04 (−0.47)	0
7	−1.98E−05 (−1.15)	6.64E−05** (3.33)	6.64E−05	2.47E−05** (3.56)	2.47E−05**
8	−1.2E−04** (−4.12)		−1.26E−04	−1.4E−04** (−6.33)	−1.4E−04**
9	−1.10E−05 (−0.71)		0	−1.59E−05 (−1.05)	0
10	−1.92E−05 (−0.54)		0	−1.14E−05 (−0.34)	0
11	−8.0E−05** (−2.90)		−8.07E−05	−8.5E−05** (−2.01)	−8.5E−05**
12	−5.9E−05** (−7.08)		−5.98E−05	−1.3E−04** (−10.67)	−1.3E−04**
13	−1.07E−04 (−1.50)		0	1.5E−04** (3.30)	1.57E−04**
14	−4.4E−05** (−3.57)		−4.40E−05	2.97E−05** (2.69)	2.97E−05**

Source: Authors' estimates, based on information from the Central Bank of Chile.

** Statistically significant at the 5 percent level.

a. The regressions are OLS estimations using intraday data from transactions conducted at Santiago's online stock market on the fourteen intervention days in 2001. Exchange rate variations are defined as ten- or twenty-minute spans, regardless of the number of transactions occurring within that period; the intervention variable is defined as the accumulated sum of interventions occurring within the time span. Lags were only included when significant. Newey-West standard errors are in parentheses.

of controls and the potential endogeneity bias in the two latter estimations, they suggest that the significant impact of individual interventions fades with time, even for time spans that are shorter than half an hour. This is consistent with the insignificant effects found for daily interventions in 2001 and with our hypothesis that the effects were channeled through the policy announcements. Intraday intervention data for 1998 do not exist, but a similar estimation should find—consistent with the daily results—a significant impact of interventions.

Conclusions and Policy Implications

The main contributions of this paper are twofold. First, it is one of the first papers to analyze the effects of exchange rate interventions for a developing economy, using official daily and intraday data. The second contribution has to do with our focus on policy announcement as an instrument through which the interventions operate. The potential use of announcements as an effective intervention instrument critically depends on the credibility associated with them. Empty promises that are not backed up by actions (in the case of the portfolio and signaling channels) or that are made by authorities who are not considered reliable (in the case of the information channel) will have no effect—or, if the market was misled this time, will weaken the effect of future announcements. Because the empirical methodology is not capable of distinguishing the specific channel through which interventions operate, it is not easy to say whether announcements must be followed by actual interventions—or even whether interventions alone have any kind of effect at all. Only under the portfolio channel must the announcement necessarily be followed by interventions, and the Central Bank must therefore have sufficient reserves for the announcement to be credible. The signaling channel, however, implies no clear need of intervening after making an announcement. Interventions here do not have an impact by themselves, but operate by revealing information on future monetary policy. The announcement arguably plays the same role, thereby making actual intervention redundant. Credibility will diminish if monetary policy (not interventions) does not behave as implicitly suggested by the announcement. Of course, actually informing the public on the authorities' willingness to change monetary policy in response to the exchange rate's behavior would be much more straightforward than indirectly resorting to intervention policy announcements.

The results found here indicate that individual interventions in Chile had a significant effect in 1998. However, the effect of individual interventions became nonexistent in 2001 and 2002. In these two years what does seem to have had an impact on expectations were the (credible) policy announcements made in both periods. Obviously, this result is conditional on the specific characteristics of the Central Bank of Chile, an institution with high levels of credibility and an important stock of international reserves. This implies that the extension of these results to other

countries, or of the policy prescriptions that could be derived from them, is not direct.

One final issue involves the definition of the effects of intervention. This paper has analyzed whether the Central Bank of Chile can affect the level of the exchange rate through the use of its intervention instruments. We do not define a benchmark against which the measured effects should be compared, however, as we do not know the specific effects the Central Bank was seeking in terms of magnitude and time length. We are not even sure whether the Central Bank was solely interested in affecting the level, or whether objectives such as reducing volatility or preventing exchange rate misalignments were also present. Given that we are testing an exchange rate model based on macroeconomic fundamentals, the effect of intervention could appear as small or insignificant if the Central Bank's objective is, precisely, to prevent the exchange rate from deviating from its fundamentals.

Comments

Oscar Landerretche: Tapia and Tokman analyze an interesting scheme for monetary policymakers in the volatile environment of emerging economies. They argue empirically that Chile has been successful in implementing a system of announced exchange rate intervention periods and that the announcements have helped to diminish the volatility of the exchange rate more than the actual interventions. Although they do not theorize profoundly on why this is true, they implicitly find evidence of the preponderance of the information channel for sterilized interventions in the exchange market. A priori this scheme is interesting because it can provide a way for central banks in emerging market to clean up their floating regimes.

Two noteworthy characteristics of the Chilean intervention regimes are perhaps insufficiently emphasized by the authors. First, the intervention periods are transitory and exceptional in the midst of a clean floating exchange rate regime. The context of these events—what makes them so exceptional—is a Central Bank that is increasingly interested in encouraging agents to get used to covering themselves against exchange rate volatility in the market. These exceptional periods will help confirm, rather than refute, the credibility of the flexible exchange rate regime as long as they are only declared when there is a clear sensation that a run against the currency is possible, if not imminent. Second, the intervention periods are announced together with a maximum reserve commitment. This is designed to keep reserves well over the benchmark for a rational run against the Central Bank, hence avoiding the possibility of contributing to the run. This also helps signal that the bank is not involved in a de facto fixation of the exchange rate within a de jure float.

Tapia and Tokman seem to show that this scheme has been effective and cheap. In fact, the actual expenditure of reserves seems to have no effect on the exchange rate. I support the notion that it is an effective scheme, but it is not as cheap as it seems, nor widely applicable among emerging economies.

In practice, the main rationale for the system is what the authors refer to as the information channel. One of the most important characteristics of this channel is that it is assumed that the exchange rate can deviate significantly from its fundamental level. This is exactly the belief that prompted the Central Bank to declare these exceptional intervention periods: namely, the Asian crisis, the Argentine turmoil, and the Brazilian scare were events that could deviate the price of the peso from fundamentals. In my view, this is an assumption of the mechanism.

In this sense, Argentine and Brazilian sneezing toward Chile is completely different from the Asian crisis. The Asian crisis involved the appearance of news that actually revealed to everybody that the fundamentals had changed. For example, it could make a lot of sense to run away from Chile when international demand for commodities is about to collapse. The Argentine and Brazilian problems were different because most people who had no money at stake were already convinced that Chile was decoupled from its larger neighbors. At the same time, investors were somewhat uncertain about the possibility of a run against the peso. The information necessary for everybody to be convinced that a significant piece of the market was not going to run against the peso seems to have been absent. What the Central Bank of Chile did was to provide a contingent asset to holders of peso-denominated instruments. The Central Bank would stop the run with its reserves and provide the market all the reserves it required if it ever seemed as if the market were ready to run. This would give the investor time to adjust optimally when a fundamental depreciation was on the way (1998) or would stop the currency from misaligning itself in the face of a possible run (2001–03). This may explain the finding of an important effect of the announcement of the intervention regime, rather than the intervention itself.

This rationalization implies several conditions for the mechanism to be effective. First, the market has to agree with the Central Bank on the possibility of the run and the justification of declaring a special intervention period. Second, the Central Bank must have the reserves or the credit lines to actually be able to intervene when it has to. Third, the Central Bank must have some source of credibility that it will use reserves to intervene as the market expects, once it has announced an intervention regime.

With regard to the first condition, quick devaluations can generate sharp deteriorations in the balance sheets of companies that intermediate credit from abroad. Moreover, such companies with direct access to international

markets are usually of significant size or strategic importance in the economy (for example, utilities). Since speculative attacks that lead to devaluations are both inflationary and recessive, central bankers prefer to prevent them if they can. However, central bankers in emerging economies often have overappreciating tendencies. Overappreciating a currency has historically been a good way of achieving quick reductions in inflation together with a credit or real estate boom. The bust and devaluation that come with the end of reserves tend to be heavily discounted. The fear, if any, is that central bankers will try to overappreciate the currency. This is why the special periods scheme is actually good for floating. It allows the Central Bank to intervene when everyone wants it to, without allowing for the overappreciating mischief that is possible in a dirty float. A crucial aspect of the scheme as implemented in Chile is that it sets a limit to the expenditure of reserves. The risk involved is that the central bank will gamble its credibility every time it declares one of these special periods, since it will basically be interpreting the fears of the market. This will probably be easier in a country where the central bank has a reputation for not messing around with the exchange rate too much.

The second condition is reserve adequacy. In many ways the Central Bank of Chile is an unusually solvent bank for an emerging economy. De Beaufort Wijnholds and Kapteyn show that Chile had a relatively high reserve adequacy in 1999 when measured against short-term debt rather than GDP or months of imports.[1] Chile currently has more international reserves than Argentina, though its economy is about 60 percent the size (in dollars) of Argentina's, and it has 30 percent the reserves of Brazil, with an economy that is 15 percent the size. Moreover, given its long history of fiscal responsibility, Chile has an excellent relationship with the International Monetary Fund (IMF), the Inter-American Development Bank (IDB), and the World Bank. This essentially means that the Central Bank has even more contingent reserves from which to draw if it ever wants to walk the walk.

Finally, there is a strange trade-off in this mechanism between precaution and credibility. If we believe in Tapia and Tokman's results, the Central Bank could potentially announce special periods every time it seemed necessary, never spend a cent of reserves, and stem all speculative attacks. Eventually, however, the market will need some proof that these inten-

1. De Beaufort Wijnholds and Kapteyn (2002).

tions are actually backed by money. The Central Bank must therefore be careful to declare special periods only when the intervention is necessary and when it is likely that it will have to intervene a bit. The fading effects of the 2002–03 episode seem to show that announcing the willingness to intervene when it is unlikely to actually happen carries a credibility cost. Hence, the mechanism may not be applicable to any other emerging economy. The same factors that make Chile a relatively attractive emerging market allow the Central Bank to keep the exchange rate from deviating violently from fundamentals by declaring that it will use its solvency and credibility if it sees that this is necessary. Insolvent central banks that have a history of exchange rate tampering or that lack independence are unlikely to be able to implement this sort of scheme successfully.

In a small, open economy like Chile, shocks will come and go. The best policy in the medium term is to develop the institutions that best insulate the country against contagion, rather than to rely on reserves and interventions. The need to defend the currency will appear time and again. These special intervention periods seem to represent a pragmatic floating of the currency that is much more clearly defined than the traditional dirty interventions.

Tapia and Tokman's evidence is encouraging, but it is very early for an evaluation. It is necessary to see how a scheme of this sort works in another country or in a different moment before coming to any conclusions. The 1998–99 episode is not clearly comparable with the other two, and the 2002–03 episode may not have been necessary. Moreover, the Central Bank of Chile was very creative and innovative in the 1990s with regard to exchange rate mechanisms and rules. Hence, it is not entirely clear that the market had internalized the rules in the first and second intervention episodes. The market may have been expecting the exchange rate bands to come back at some moment and may have interpreted these announcements as a movement in that direction. It will be interesting to see the application and performance of this scheme the next time that the ghouls of contagion come screaming over the Andes.

Roberto Rigobón: The problem of estimating how effective a central bank is in affecting the exchange rate is perhaps one of the most debated questions in international economics—and for very good reasons. Markets believe that central banks have the power to affect the exchange rate; this is easily reflected in the tremendous attention that markets devote to

central bank announcements regarding the nominal or the real exchange rate. Central banks intervene frequently and sometimes make announcements regarding what they believe should be the exchange rate—and unless they are in the business of just adding noise to the market, this behavior reflects the fact that they also believe that they can affect the exchange rate. This supposedly strong power of the central bank is hard to find, however, based on either the data or what theory predicts.

Indeed, OLS estimates of the impact of interventions on exchange rates are usually biased owing to the problem of simultaneous equations. The central hypothesis is that intervention affects the exchange rate, but the decision to intervene is not independent of the movements in the exchange rate. Moreover, even once a central bank has decided to intervene, the quantity of currency it buys or sells and its timing will typically depend on the response of the exchange rate to its trades. The literature generally deals with the simultaneous equations problem by assuming that the contemporaneous decision of the central bank is independent of the current innovations to the exchange rate. This is a strong assumption at daily frequencies. For example, it implies that the central bank does not change its selling or buying behavior by assessing the impact its actions have had on the exchange rate.

Matías and Andrea's paper contributes to this discussion by estimating the impact of the Central Bank's intention to intervene. Although they estimate the contemporaneous impact of interventions on the exchange rate, their most important contribution is that the Central Bank's announcements signaling its willingness to intervene in a certain direction were very effective in moving the exchange rate in the Chilean experience. In this discussion, I concentrate on the tremendous endogeneity problem that exists in the data, even when the coefficients are estimated using ten-minute data. This should indicate how important their contribution is.

The Endogeneity Problem and the OLS Bounds

I propose the following simple model of central bank intervention:

$$e_t = \alpha\, i_t + \varepsilon_t \text{ and} \tag{1}$$

$$i_t = \beta\, e_t + \eta_t,$$

where e_t is the nominal exchange rate change and i_t is the intervention by the central bank. The first equation indicates how intervention affects the nominal exchange rate, and the second equation summarizes the central bank's intervention decision. Under the interpretation that the central bank leans against the wind, I would expect the first coefficient (α) to be negative and the second one (β) to be positive.

This model abstracts from other important issues in the intervention problem, such as the nonlinearities of the intervention (Central Banks do not intervene most of the time, but rather only when deviations are perceived to be large enough) and common shocks (clearly, factors that are not related to either exchange rate innovations or intervention decisions move both exchange rates and interventions). The purpose of this discussion, however, is to concentrate on the endogeneity problem, and this setup illustrates the problem.[1]

The severity of the endogeneity problem can be assessed by what is called reversed regressions, or the OLS bounds. In this simple setup, this method determines the bounds where the true coefficient lies. It was proposed by Leontief and recovered by Leamer and Edwards.[2]

The general problem of simultaneous equations can be summarized by the simple relationship

$$e_t = a\, i_t + \nu_t,$$

where the right-hand-side variable, i_t, is correlated with the residual ν_t. This is exactly the first equation in the system of equations, but here I would like to discuss when this correlation arises from multiple sources, not just from reverse causality.

The variable a cannot be estimated consistently in the presence of these misspecifications. Indeed, there are two forms of estimating a:

(2a) $$e_t = a\, i_t + \nu_t \text{ and}$$

(2b) $$i_t = \frac{1}{a} e_t + \bar{\nu}_t$$
$$= b\, e_t + \bar{\nu}_t.$$

1. For a detailed discussion of the estimation problem, see Kearns and Rigobon (2003).
2. Leontief (1929); Leamer (1981); Edwards (1992).

Both regressions are equally wrong! Leontief studied this problem and realized that depending on the sources of the misspecification, the OLS estimates in these regressions provide bounds for the true coefficient. In particular, assume that the true model is given by equation 1. The OLS estimate in equation 2a is then

$$\hat{a}_{2a} = (i_t'i_t)^{-1}i_t'e_t = \alpha + \beta(1-\alpha\beta)\frac{\sigma_\varepsilon^2}{\sigma_\eta^2 + \beta^2\sigma_\varepsilon^2},$$

while the estimate of $1/a$ in equation 2b is

$$\hat{b}_{2b} = (e_t'e_t)^{-1}e_t'i_t = \beta + \alpha(1-\alpha\beta)\frac{\sigma_\eta^2}{\alpha^2\sigma_\eta^2 + \sigma_\varepsilon^2}$$

$$= \frac{1}{\alpha} - \frac{1}{\alpha}(1-\alpha\beta)\frac{\sigma_\varepsilon^2}{\alpha^2\sigma_\eta^2 + \sigma_\varepsilon^2}.$$

If one is interested in a, one can solve $\hat{b}_{2b}$ for $1/\alpha$ instead of b. In fact, both estimates, $\hat{a}_{2a}$ and $\hat{b}_{2b}$, can be used to compute the range in which the true coefficient a must lie if the model is correct. To illustrate the range, consider the case in which a and b have different signs.[3] If a and b have different signs, the bias in equation 2a makes the OLS coefficient smaller (in absolute value) than the true one. In other words,

$$|\hat{a}_{2a}| < |\alpha|.$$

Similarly, the bias is also toward zero in equation 2b. I can thus write

$$|\hat{b}_{2b}| < \left|\frac{1}{\alpha}\right|.$$

Therefore,

$$|\hat{a}_{2a}| < |\alpha| < \left|\frac{1}{\hat{b}_{2b}}\right|.$$

In other words, if the two schedules have different signs, then the true coefficient lies between the two estimates; this is exactly why this method

3. See Lee, Ricci, and Rigobon (2003) for a general discussion of the bounds for all the cases.

determines the bounds. If the problem of simultaneous equations is small, the two bounds should be close.

DAILY DATA. The next step, therefore, is to compute the bounds for the daily and intraday data.[4] Using daily data the bounds are as follows (after some normalization): for equation 2a, the point estimate of *a* is 0.11, with a standard deviation of 0.05; for equation 2b, the inverse of the point estimate is 34.74, with a standard deviation (using the Delta method) of 16.85. A test of whether the point estimates are statistically different yields a result of 2.05, rejecting the hypothesis that the estimates are statistically different. Although this is important, it is not the crucial dimension I would like to highlight.

Based on these derivations, I concluded that the true coefficient lies between these two estimates—which is a very large confidence interval. The assumption that the estimate in the first column is correct raises an inference problem: while it would be tempting to say that the estimate is 0.11 and that it is between 0.01 and 0.21, this process is incorrect. This is not the estimate of the intervention's effectiveness, but the estimate of the lower bound of the estimate—and even though the lower bound is precisely estimated, the true coefficient is between 0.11 and 34.74. What is even worse is the fact that the estimates are positive instead of negative! This suggests that when the central bank intervenes, the exchange rate moves in the wrong direction.

INTRADAY DATA. Several papers in the literature concentrate on extremely high frequency data as a means of solving the endogeneity problem. The argument is that looking at the data every ten minutes should dramatically reduce the simultaneous equations issue.

Table 7 presents estimates of the bounds for each of the fourteen days in the sample. Most of the estimates are negative, suggesting that the endogeneity problem is not as severe as it is in the daily data. The bounds are still extremely large in relative terms, however: the upper bounds are consistently a hundred times the lower bounds. While there are fewer rejections in this case—the upper and lower bounds are statistically different in only four of the fourteen days—the distance between the lower and upper bounds indicates that the endogeneity problem is still important, even when the data are collected every ten to twenty minutes. This exercise

4. I thank Andrea and Matías for providing me with the regression results. The data are confidential, and hence I appreciate their efforts.

TABLE 7. Estimates of the Bound Based on Intraday Data

	Equation 2a		*Equation 2b*		
Day	*Point estimate*	*Standard deviation*	*Point estimate*	*Standard deviation*	t *statistic*
1	−1.50	0.49	−284.94	251.81	1.13
2	−2.41	0.70	−30.73	13.11	2.16
3	−1.98	0.85	−12.70	8.83	1.21
4	−0.64	0.52	−55.61	50.33	1.09
5	−1.72	0.57	−17.29	4.74	3.26
6	−5.02	0.68	−13.63	7.57	1.13
7	−0.81	0.27	−12.06	5.29	2.12
8	−0.50	0.40	−13.06	11.22	1.12
9	−0.24	0.10	−8.97	3.50	2.49
10	−0.22	0.14	−3.65	3.13	1.09
11	−0.26	0.00	−4.77	4.62	0.98
12	−0.48	0.10	−8.79	6.35	1.31
13	0.28	0.00	42.11	43.66	0.96
14	−0.04	0.07	−24.47	44.90	0.54

shows that the problem of estimating the effectiveness of central bank interventions cannot be solved by concentrating on extremely high frequency data alone; the solution is somewhere else.

The problem of estimating whether interventions are effective is one of the most challenging problems in empirical open economy macroeconomics. In my paper with Jonathan Kearns, we devise a procedure that is able to solve the problem, but its applicability is quite limited and, in particular, it cannot be used in the Chilean case.[5]

Since the estimation issue cannot be solved by looking at extremely high frequencies, what can be done? Andrea and Matías offer a different perspective. Instead of concentrating on the problem of directly estimating the impact of interventions on the exchange rates, they looked at a possibly less endogenous variable—namely, the Central Bank's decision and announcement of its intention to intervene. Future research should continue to study this issue, and creative avenues such as the one proposed by Andrea and Matías are likely to be prolific.

5. Kearns and Rigobon (2003).

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