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Singular Focus or Multiple Objectives? What the Data Tell Us about Inflation Targeting in Latin America

Introduction

In the last decade and a half several Latin American countries have adopted inflation targeting as their monetary framework, moving away from other intermediate targets, such as monetary aggregates, and allowing, at least on paper, more exchange rate flexibility. While the literature so far has not delivered a clear verdict on the impact of inflation targeting on macroeconomic performance in general—particularly in comparison to other monetary frameworks that have faced the same global environment—it is evident that countries that have adopted inflation targeting have generally succeeded both in stabilizing inflation at relatively low rates and in anchoring the public's expectations at levels near the target.[1]

One recurring question that arises regarding the use of inflation targeting concerns the flexibility that policymakers need to implement it. Namely, to what extent should exchange rate fluctuations or financial stability concerns also be incorporated into the policy of a central bank that aims at achieving a preannounced target for inflation? This is particularly relevant given that such targeting relies critically on policy credibility and effective communication with the public, thus the perception that multiple—and possibly

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1. See Agénor and Pereira da Silva (2013) for a comprehensive review of the evidence.

conflicting—objectives are being pursued might undermine such credibility, thereby endangering the integrity of the policy.

Regarding the exchange rate, the question is whether inflation targeting can or should accommodate a certain degree of "fear of floating" (Calvo and Reinhart, 2002)—that is, a policy reaction directed at preventing or smoothing out exchange rate fluctuations. In the most narrow sense, it is clear that central banks using inflation targeting should respond to these movements when, via a pass-through, they are likely to be transmitted to inflation or inflationary expectations. However, beyond this pass-through effect, there is also a case for reacting to exchange rate movements, as these could generate supply-side effects through their impact on the prices of intermediate inputs. They could also affect competitiveness and—particularly in highly dollarized economies—lead to balance-sheet effects that feed into financial instability.

In fact, there is evidence that countries using inflation targeting do react to exchange rate movements. Estimating a monetary reaction function for a panel of advanced and emerging economies during 1996–2011, Muñoz and Schmidt-Hebbel (2012) find that the short-term policy rate in countries both with and without inflation targeting (known as IT) reacts to changes in the nominal exchange rate. Using a similar approach, but focusing on emerging economies, Aizenman, Hutchinson, and Noy (2011) find that the policy rate reacts to changes in the real exchange rate, particularly in commodity exporting countries. Note that it is not possible to determine from these studies whether there is a separate exchange rate objective at play, as opposed to the exchange rate being treated as one more signal regarding future inflationary pressures. From a different perspective, Berganza and Broto (2012) focus their attention directly on foreign exchange (forex) interventions by central banks. Consistent with the presumed greater exchange rate flexibility of IT, they find that exchange rates are indeed more volatile in inflation-targeting countries than in countries that do not target inflation. However, forex intervention is far from absent in the targeting countries, and it is found to be effective in reducing exchange rate volatility.

On the second question, whether financial stability concerns should be incorporated into an inflation-targeting framework, there is also a case for expanding the set of instruments at the disposal of policymakers—making use of macroprudential tools such as dynamic provisioning, countercyclical capital requirements, and loan-to-value limits—and even complementing these instruments with an explicit reaction of the policy rate to an appropriate

financial stability indicator. Particularly in the aftermath of the global financial crisis, there is recognition that monetary policy focused too narrowly on achieving low and stable inflation might have played a role in creating the conditions for severe financial sector imbalances. Consequently, there now seems to be broad agreement that financial stability can be a policy goal as important as macroeconomic stability. Agénor and Pereira da Silva (2013) propose an "integrated inflation-targeting" framework that addresses both objectives and that entails an augmented central bank reaction function featuring a response to some measure of a "private credit gap" that can signal possible emerging financial imbalances. Muñoz and Schmidt-Hebbel (2012) find evidence that policy rates in inflation-targeting countries respond to one such measure: the growth of nominal credit to the private sector. Note that, as in the case with response to exchange rate movements, this result does not necessarily imply that financial stability is being explicitly built into the reaction function, since credit growth can simply be used as a leading indicator for future movements in output or prices.

This paper focuses on four countries in Latin America—Brazil, Chile, Colombia, and Peru—during the 2000–12 period, covering virtually their entire experience so far with inflation targeting. These countries, together with Mexico, were the original inflation-targeting countries in Latin America. We assess in general how they conducted such targeting and, in particular, how flexible they have been in terms of incorporating a response to exchange rate movements and possible financial stability concerns. Contrary to the studies mentioned, we focus on individual country experiences and adopt a flexible approach that allows us to discern cross-country heterogeneity as well as possible structural breaks over time.

We undertake two analytical exercises. First, we estimate country-specific monetary reaction functions using Markov switching, a methodology that enables us to detect whether regime switches have taken place. The flexibility offered by this approach allows us to ask several questions regarding how inflation targeting has evolved and how flexible it has been. Furthermore, this methodology allows the data to speak for themselves, since the dates of these shifts are not determined ex ante. Specifically, the Markov switching approach allows us to ask the following questions, which shed light on the flexibility of inflation targeting in these countries:

—How stable has the policy rule been over time?

—Has there been a change in credibility of monetary policy? Given that credibility is a work in progress, enhanced credibility would be reflected in a

reduction in the response to the inflation gap or an increase in the response to other arguments in the reaction function.[2]

—Has there been a "fear of floating" response to exchange rate movements, either as an indication of pass-through to domestic prices or as a separate objective?

—Has financial stability been incorporated into the reaction function through a private credit gap measure, particularly in recent years, when countries introduced a host of macroeconomic prudential measures to complement monetary policy?[3]

—Has the response to the exchange rate or the private credit gap been systematic over the entire period, or episodic, arising only in certain brief periods?

—Are there observable changes in behavior surrounding major events, such as the global financial crisis?

In our second analytical exercise, we turn our attention to the drivers of central bank forex intervention, in essence to discern a policy rule analogous to a monetary reaction function. We are particularly interested in testing whether such intervention is, as claimed by most central banks, driven by concerns with exchange rate volatility or rather if there is evidence of a level objective for the exchange rate. Such an analysis of forex intervention allows us to ask several questions:

—Does intervention respond to perceived real exchange rate misalignments, and if so, is the response symmetric, treating depreciations and appreciations equally?

—Does intervention respond to increases in exchange rate volatility?

—Does the level of international reserves play a role? That is, is there evidence that intervention serves to establish a certain level of reserves?

Our main findings are as follows. The Markov switching analysis shows that monetary reaction functions in the four countries were remarkably stable throughout. The estimation yields a dominant regime, applying to more than 90 percent of the observations. In that sense, there is no evidence of an enhancement in credibility, in terms of a shift from an initial regime with a relatively strong response to the inflation gap to a posterior regime with a

2. In other words, as credibility increases, central bank policy can obtain benefits through an expectations channel. Given the same shock, the central bank will be able to bring inflation back to target with a smaller response to the inflation gap. More generally, as credibility increases, the central bank can afford to be less orthodox and more flexible in its response, possibly incorporating exchange rates and financial stability concerns.

3. Barajas and others (2014) provide a description of these macroprudential measures.

relatively weak response, nor do responses to exchange rate or private credit gaps exhibit a discernible regime shift. Rather, these responses were stable throughout the period: Colombia exhibited sensitivity to a real exchange rate gap and Chile to a private credit gap. The departures from the dominant regime were infrequent and short-lived, clustered around episodes of turmoil, in particular the global financial crisis. When departures occurred, it was difficult to determine the rule at play, but they generally resulted in a policy rate lower than would have followed from the conventional rule.

From our analysis of forex intervention, we find evidence of fear of floating. Interventions respond to real exchange rate gaps and generally do so in an asymmetric fashion, appreciations triggering a stronger intervention than depreciations. Exchange rate volatility appears to trigger greater intervention only in Brazil, and we find little evidence that intervention was driven by an effort to increase international reserves. In summary, we find that inflation targeting has been flexible in these countries. It has been resilient to domestic and external shocks, allowing for sporadic departures from the "dominant" rule during certain extreme events; it has also coexisted with some degree of fear of floating and, in the case of Chile, has incorporated financial stability concerns into the reaction function without noticeably sacrificing credibility.

Monetary Policy in Four Latin American Countries

We analyze monetary policy in the four countries by estimating several versions of a reaction function for the central bank. We first specify a conventional Taylor rule in which the policy rate responds to the output and inflation gaps, then an expanded policy rule consistent with integrated inflation targeting, whereby the policy rate might respond to the exchange rate and credit gaps as well. For both specifications, we first estimate the rule under the assumption that the parameters remain constant throughout the sample period (OLS), then we allow for discrete changes in parameters (Markov Switching).

Estimating a Conventional Taylor Rule

At its most basic, a conventional Taylor rule summarizes the monetary reaction function under inflation targeting as follows:

$$i_t = \alpha + \beta_1 i_{t-1} + \beta_2 x_t + \beta_3 (E_t \pi_{t+1} - \pi_t^T) + \varepsilon_t. \quad (1)$$

TABLE 1. Definition of Variables[a]

Variable	*Symbol*	*Description*
Policy rate	i	Country policy rate of interest
Output gap	x_t	(y – y *hp*)/y *hp,* where y *hp* is trend GDP obtained from an HP filter
Inflation gap 1	π^1	Inflation expectations (from Latin Focus consensus forecast) minus the inflation target
Inflation gap 2	π^2	Inflation (according to the consumer price index) minus the inflation target
Inflation gap 3	π^3	Inflation expectations
Inflation gap 4	π^4	Inflation
RER percent deviations from trend	$RER_d hp$	(*RER* – *RER hp*)/*RER hp,* where *RER hp* is trend RER obtained from an HP filter
Credit gap	$C1$	$\partial RC/RC - \partial Y/Y_t$, where *RC* is real gross loans and *Y* is real output
Financial deepening	$C2$	*RC*/*GDP*
Nonperforming loans	$C3$	Nonperforming loans in real terms/RC

a. Appendixes A through D report the exact definition and source of each variable in each country. The frequency of the data is monthly, from January 2000 to September 2012.

Thus, the policymaker would be expected to adjust the policy rate in response to the differential in the expected inflation rate $E_t\pi_{t+1}$ over the inflation target π_t^T—that is, the inflation gap—and to the output gap x_t. In addition, since there may be costs involved in introducing too much variability in the policy rate, interest rate smoothing is incorporated through the lagged interest rate term i_{t-1}. In this plain vanilla reaction function, these are the only variables that should be considered, and for a traditional, or strict inflation-targeting, country one could reasonably expect the sensitivity parameters β_1, β_2, and β_3 to remain stable over time. Table 1 presents the definitions of all variables used in the regressions in this paper.

The OLS estimation of 1 is reported in table 2 (short-term coefficients) and in table 3 (long-term coefficients, equal to the short-term coefficients divided by 1 minus the sum of the coefficients of the lagged dependent variable). Results are as expected for all countries except Peru. In particular, in all four countries the policy rate reacts positively and significantly to the output gap, but the response to the inflation gap is positive and significant in all but Peru.[4]

These results are similar to those obtained in previous studies (table 4). In general, in Colombia and Chile the policy rate reacts positively and significantly to output and inflation gaps. Among the four countries, Chile consistently reports the highest response to the inflation gap, while in Peru the

4. We also undertook this exercise using quarterly data; results are consistent with those using monthly data (Barajas and others, 2014).

TABLE 2. Taylor Rule Estimation (OLS), Short-Term Coefficients[a]

Description	*Brazil*	*Chile*	*Colombia*	*Peru*
Intercept	0.31*	0.36***	0.15**	0.38***
	(0.05)	(0.00)	(0.04)	(0.00)
$\sum_{0}^{4} i_{t-1}$	0.91***	0.93***	0.95***	1.02***
	(0.00)	(0.00)	(0.00)	(0.00)
x_t	0.09***	0.05*	0.03***	0.10***
	(0.00)	(0.06)	(0.00)	(0.00)
π^1	0.08*	0.22**	0.12**	0.04
	(0.05)	(0.03)	(0.04)	(0.45)
R^2	0.97	0.94	0.98	0.93
Observations	152	152	152	130
D-W test	1.9	0.03	0.88	0.75
(χ2)	(0.16)	(0.85)	(0.34)	(0.24)

Source: Authors' calculations.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
a. *p*-values in parentheses.

estimated parameters for the Taylor rule change visibly from study to study. Of particular interest is that our estimates support the fact that in Chile and Colombia the coefficient for the inflation gap is significantly greater than 1; that is, in response to an increase in the inflation gap, the central bank increases its (ex ante) real rate of interest, not just its nominal rate. This stability condition for the Taylor rule is not verified in Brazil and Peru, in accordance with findings in previous studies.

Markov Switching Estimation of the Taylor Rule

To capture possible changes in the policy rule over time as well as additional variables being considered in the rule (*Wt*; see next section), we propose an extension of the reaction function 1 that allows sensitivity parameters

TABLE 3. Taylor Rule Estimation (OLS), Long-Term Coefficients[a]

Description	*Brazil*	*Chile*	*Colombia*	*Peru*
x_t	0.89***	0.85*	0.6***	n.c.
π^1	0.78**	3.14***	2.4**	n.c.

Source: Authors' calculations.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
a. *p*-values in parentheses. Since the lagged coefficient of the interest rate is greater than 1, there are no meaningful long-term coefficients in the case of Peru.

TABLE 4. Taylor Rule, Long-Term Responses[a]

Description	*Brazil*	*Chile*	*Colombia*	*Peru*
OLS-IT (2000–12)				
Output gap	0.89***	0.85*	0.6***	n.c.
Inflation gap	0.78**	3.02***	2.4**	n.c.
OLS-IIT (2000–12)				
Output gap	0.63***	0.55***	0.6***	n.c.
Inflation gap	0.36	2.33***	3.2**	n.c.
Exchange rate	0.007	0.04	0.08	n.c.
Credit gap	–0.009	0.03	–0.06	n.c.
GMM[b] (1999–2007)				
Output gap	n.a	1.18***	1.28***	0.27**
Inflation	n.a	1.43***	–0.03	–0.73**
Exchange rate	n.a	–0.006	0.09**	–0.09**
OLS[c] (1999–2008)				
Output gap	0.18	0.26**	0.35**	0.64
Inflation gap	0.62***	3.05***	0.76	0.34
Exchange rate	–0.62	–0.15	0	228
SVAR (1999–2006)				
Output gap	0.03**	–0.05	0.00	n.a.
Inflation gap	0.56**	0.30**	–0.38	n.a.
Exchange rate	0.06	–0.43	–0.41	n.a.

Source: Mehrotra and Sánchez-Fung (2011); Moura and Carvalho (2009); Mello and Moccero (2011).
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
a. *p*-values in parentheses.
b. GMM: generalized method of moments. The instruments are lags 2 and 3 of the interest rate and lags 1 and 2 of the inflation gap, the output gap, and the exchange rate.
c. Authors estimate the Taylor rule by OLS with Newey-West robust standard error. They use the HP filter for each variable definition.

to change over time: a Markov switching methodology based on Hamilton (1994).[5] It has the following form:

$$i_t = \alpha^{S_t} + \beta_1^{S_t} i_{t-1} + \beta_2^{S_t} x_t + \beta_3^{S_t}(E_t\pi_{t+1} - \pi_t^T) + \gamma^{S_t} Wt + \sigma^{S_t}\varepsilon_t. \quad (2)$$

Each sensitivity parameter—as well as the residual variance σ—is allowed to vary across states *S*. The Markov switching approach to the monetary

5. It is assumed that $S_t \in S = \{1, \ldots, n\}$, where *S* is the set of states. It is also assumed that $\varepsilon_t \sim$ i.i.d $N(0,1)$, and S_t is independent of ε_τ for all t and τ. A time-homogeneous Markov chain of order 1 governs the probability of changes in regime S_t, where $p_{ij} = P(S_t = i|S_{t-1} = j)$ is the probability of being in state i at time t given that state j was present at time $t - 1$. These probabilities are assumed to be independent of past values of i_t (policy rate) and current and past values of exogenous variables.

reaction function has been applied primarily in industrialized countries. Assenmacher-Wesche (2006) used it for the United States, the United Kingdom, and Germany, and Creel and Hubert (2009) conducted a similar exercise for Canada, Sweden, and the United Kingdom. Both studies were able to discern periods in which monetary policy was relatively more hawkish or more dovish—that is, reacting more (less) vigorously to the inflation differential and less (more) to the output gap. To the best of our knowledge, our study is among the first that applies this methodology to emerging inflation-targeting economies, where the case for a more flexible regime is probably stronger and where it seems likely that, as the regime matured and macroeconomic conditions evolved, the rule itself changed as well.[6]

This approach has the appealing feature that it "lets the data speak"; we do not impose our ex ante views on when the changes in the practice are likely to occur. The methodology sorts out where the statistical behavior of the variables changes significantly, providing us with dates at which the structural breaks actually occur. We can then contrast these results with observed shocks and identified announcements of policy changes to give an intuitive sense of the effective changes in policy behavior. It is important to note that, rather than a small change in the relative response of the policy rate to the different signals, there may be extreme periods in which the policy rule is abandoned altogether in favor of discretion or in response to changes in the broader macroeconomic environment that are not easily captured by the reaction function.

Specifically, the Markov switching approach to the monetary reaction function allows us to ask the following questions: How stable has the policy rule been over time? Has there been a change in credibility of monetary policy? Has there been fear of floating in the form of a response to exchange rate movements? Have financial stability concerns been incorporated into the reaction function? Has the response to exchange rate or private credit gap been systematic over the entire period? Or has it been episodic, arising only in brief periods? Are there observable changes in behavior surrounding major events, for example, the global financial crisis?

The results of these estimations are reported in table 5 (short-term coefficients) and in table 6 (long-term coefficients). In table 5 there are two columns for each country, one for each regime identified by the econometric

6. In a related study, Barajas and others (2012) explore a simplified version of the above model, focusing on reactions to the exchange rate in a sample of emerging inflation-targeting countries.

TABLE 5. Markov Switching Estimation of the Taylor Rule, Short-Term Coefficients, by Inflation-Targeting Regime[a]

	Brazil Regime		*Chile Regime*		*Colombia Regime*		*Peru Regime*	
Description	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*
Intercept	0.31**	−0.95	0.13***	0.13	0.17***	−0.16	0.17***	−0.15
	(0.05)	(1.00)	(0.00)	(0.99)	(0.00)	(0.82)	(0.00)	(0.94)
$\sum_{0}^{4} i_{t-1}$	0.88***	5.4	0.97***	0.88	0.92***	0.84**	0.95***	0.82
	(0.00)	(0.89)	(0.00)	(0.78)	(0.00)	(0.03)	(0.00)	(0.11)
x_t	0.08***	−0.65	0.03*	−0.03	0.03***	−0.03	0.02*	−0.05
	(0.00)	(1.00)	(0.06)	(0.99)	(0.00)	(0.83)	(0.06)	(0.85)
π^1	0.07**	−0.76	0.09***	−0.35	0.07*	−0.20	0.05**	0.11
	(0.05)	(1.00)	(0.00)	(0.95)	(0.05)	(0.60)	(0.04)	(0.95)
σ^2	0.23***	491.1	0.02***	49.1	0.02***	0.75	0.01***	1.8
	(0.00)	(1.00)	(0.00)	(1.00)	(0.00)	(1.00)	(0.00)	(1.00)
$p = p^{11}$	1.00		0.97***		0.97***		0.98***	
	(0.83)		(0.00)		(0.00)		(0.00)	
Number of months in regime	152	0	142	10	137	15	121	8
L	104.16		51.12		10.34		59.51	

Source: Authors' calculations.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
a. *p*-values in parentheses. The long-term coefficients of regime 1 are reported in table 6.

procedure.[7] The upper portion of the table reports the estimated coefficients in each regime, while the bottom portion shows relevant statistics. First shown is the frequency of observations in which each regime is most likely.[8] And $p = P^{11}$ is the probability of remaining in regime 1 in period *t,* given that the economy is in that state in $t-1$. Both show that regime 1 is dominant, with all four countries spending an overwhelming majority of the period in this regime. In fact, for Brazil, regime 2 is all but ruled out, as regime 1 has at least a 90 percent probability of occurring in every observation in the sample period. Second, the table reports *L,* the final value of the log likelihood function maximization. Third, the table reports σ, the model residual variance, for which significant switching across regimes is identified.[9]

7. In principle, it is conceivable to have any number of different regimes within a given sample period, although the statistical procedure may struggle to distinguish separate regimes past a certain number. We decided to settle on identifying two regimes, as estimation of the Markov switching methodology with three regimes yielded a third regime that had essentially zero probability of occurring throughout the sample period. These results are available upon request.

8. That is, when the estimated probability of being in a given regime is at least 90 percent.

9. Additionally, with four lags of the interest rate, a Ljung-Box-Pierce Q-test test indicates that there is no first- to tenth-order autocorrelation in any country.

TABLE 6. Markov Switching Estimation of the Taylor Rule, Long-Term Coefficients, Inflation-Targeting Regime 1[a]

Description	*Brazil*	*Chile*	*Colombia*	*Peru*
x_t	0.75***	0.85*	0.39***	0.4*
π^1	0.68**	3.25***	0.95*	1**

Source: Authors' calculations.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

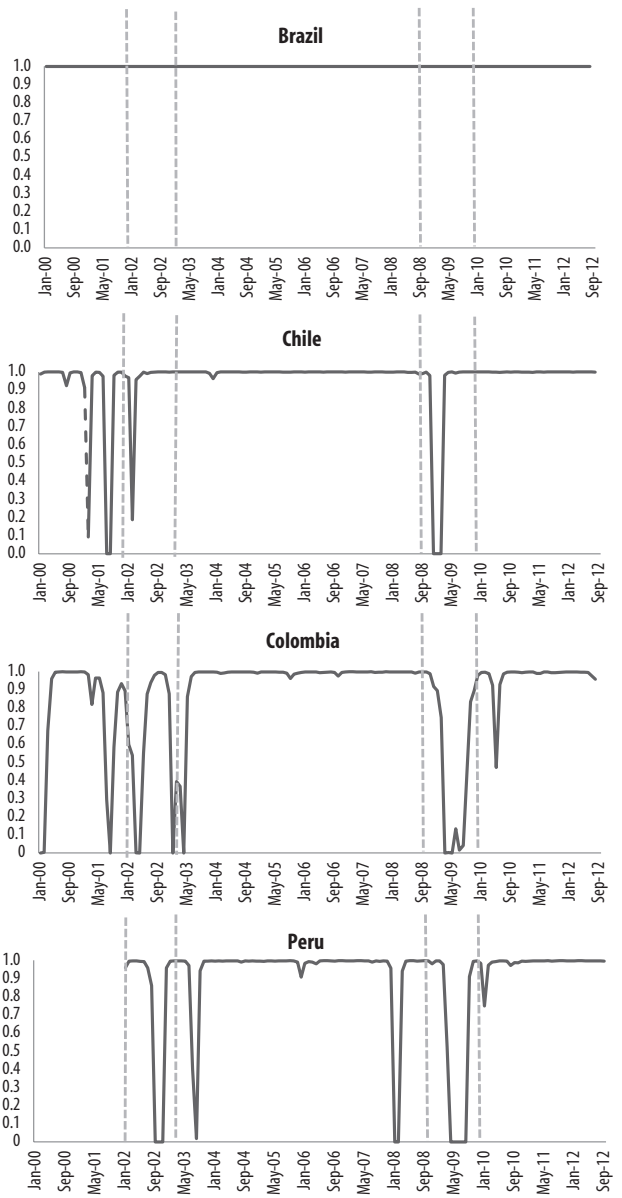
In comparison to the OLS results reported in table 5, two points are worth highlighting. First, once the possibility of structural change is allowed for, there is now evidence of a standard Taylor rule operating in the case of Peru, with positive and significant coefficients for both output and the inflation gap. Second, there is an important reduction in the coefficient measuring the response of the policy rate to the inflation gap in the case of Colombia.

Regime 2 may be characterized as a series of discretionary episodes, sporadic and short-lived abandonments of the normal reaction function. Although the econometric procedure identifies two regimes for each country, in none of the four countries are any of the Taylor rule parameters significant in regime 2. Therefore the policy rule is not easily understood, given that the determinants of the policy rate are not captured by the conventional variables. This lack of significance is also reflected in the striking difference in residual variance between regimes—for example, 0.02 in regime 1 in Peru as compared to 49.1 in regime 2—which also may be due to increased volatility during the short-lived regime 2 episodes. Note that the switch in residual variance is most pronounced in the case of Brazil, where regime 2 essentially never occurs as a reasonable predictor of interest rate behavior.[10]

In figure 1 one can observe that regime 2 periods greatly coincide across countries. In particular, two episodes stand out where there was significant turmoil in international financial markets. The first was in 2001 and 2002, when markets became very hostile toward emerging markets, in part due to the Argentinean crisis and also as a consequence of the very negative expectations surrounding the possibility of Lula da Silva's election in 2002. The second was in late 2008, following the collapse of Lehman Brothers. In both instances, results indicate that the central banks of Chile, Colombia,

10. Although the procedure forcefully estimates an alternative regime, for all intents and purposes regime 2 is irrelevant in this specification for Brazil. This result is corroborated in figure 2, where the probability of being in regime 2 is 0; that is, regime 2 never "occurs" at any probability cutoff. For the purposes of this discussion, regime 1 "occurs" when its estimated probability is at least 90 percent. Otherwise, regime 2 "occurs."

FIGURE 1. Regime Switching, Four South American Countries[a]



Source: Authors' calculations.

a. The figure reports probabilities of being in regime 1 for the specifications in table 6.

TABLE 7. Main Episodes of Regime Change, Chile, Colombia, Peru

Country	*Period*	*Motivation*	*Policy Actions*
Chile	Between May and September 2001	Significant increase in risk perceptions on account of events in Argentina and a persistent decline in the price of copper.	—The central bank lowered the repo rate in 2001 from 5.25% in February to 3.5% in July. —In August it announced that it would sell up to $2 billion of international reserves in the spot market for the rest of the year.
	Between January and May 2009	Collapse of Lehman Brothers and increase from 189 to 307 bps in sovereign spreads between September and October 2008.	—At the end of September the central bank announced the end of a $8 billion international reserve accumulation program announced in April 2008 and began a program of repos and swaps. —The central bank lowered the repo rate in 2009 from 7.25% in February to 0.5% in August.
Colombia	Mid-2001 to mid-2002	Inflationary pressures coupled with supply-side weakness and adverse TOT shocks.	—Between June 2001 and July 2002 the central bank cut the repo rate seven times, from 11.5% to 5.25%. —In parallel, it injected liquidity with purchases of foreign reserves ($650 million) and of public debt in the secondary market.
	Late 2002 to mid-2003	This period included a "domestic public debt crisis" and spillover effects from the uncertainty surrounding the victory of Lula da Silva in the Brazilian election.	—In August 2002 the central bank brought forward its preannounced permanent purchases of public debt in the secondary market and authorized stockbrokers and trust companies to undertake monetary operations with the central bank. —The repo rate remained unchanged throughout the second half of 2002 while the central bank sold $545 million of NIR.
	January 2009 to August 2009	Collapse of Lehman Brothers and a trade embargo by Venezuela and Ecuador that contributed to a sharp contraction of exports between January and May.	—The central bank removed all controls on capital inflows in September 2008 and reduced reserve requirements in October. —The central bank aggressively reduced the repo rate, from 10% in December 2008 to 4% in October 2009. —The central bank decided that most of the additional liquidity to be provided toward the end of 2009 would be on account of NIR purchases and purchases of public debt.
Peru	September to December 2002	Uncertainty surrounding the Brazilian election.	—The central bank raised the interbank rate from 2.9% in July to 5.4% in September. —In addition, it sold $127 million in the open market in September 2003.
	May to August 2009	Collapse of Lehman Brothers.	—In September 2008 the central bank lowered reserve requirements on short-term bank deposits held by foreign residents from 120% to 35%. —It sold $6.8 billion NIR between September 2008 and March 2009. —Between September 2008 and February 2009 it lowered to 6% marginal reserve requirements on domestic currency bank deposits. —Finally, the central bank lowered the repo rate almost 500 bps between February and August 2009.

Source: Monetary Policy Reports; Financial Stability Reports; Chang (2007); Céspedes, Chang, and Velasco (2010); Kamil (2008); Vargas and others (2010).

TABLE 8. Actual versus Estimated Policy Rate during the Lehman Crisis, in Chile, Colombia, Peru[a]

Country	*Period*	*Actual average policy rate*	*Regime 1 policy rate*
Chile	January–May (2009)	4.85	6.21
Colombia	January–June (2009)	7.80	7.99
Peru	May–August (2009)	2.77	3.69

Source: Authors' calculations.
a. The period for the average was chosen according to the regime-switching results.

and Peru abandoned their well-behaved, conventional Taylor rule. Table 7 summarizes the main events and policy actions in Chile, Colombia, and Peru during the episodes (identified as being in regime 2, according to Markov switching estimations).

In several of the episodes summarized in table 7, central bank policy went beyond what the usual (regime 1) reaction function would have called for. In particular, central banks maintained a looser monetary policy stance and complemented low policy interest rates with other tools (that is, liquidity injections and exchange market intervention). In Chile's first episode, copper prices may have given signals of a stronger downturn than those reflected in the output gap, while in Colombia's first episode, political turmoil and its possible effects on output led the central bank to loosen further, even as inflation was above target. The Lehman bankruptcy and uncertainties surrounding the impending Lula presidency seem to have led central banks to consider potential spillovers that had not yet materialized in the output gap, thus spurring them to respond more aggressively than usual. Table 8 illustrates the relative looseness of the regime 2 episodes following the Lehman collapse, where the policy rate was kept below the predicted (regime 1) level in all three countries, particularly in Chile and Peru.

Integrated Inflation Targeting?

Following the recent financial crisis, increased attention is being paid to the need for policy to focus not only on macroeconomic stability but also on financial stability. In fact, the view has been expressed that success with regard to macroeconomic stability—in particular, success in achieving low and stable inflation—might have led to complacency with regard to the monetary policy stance, in effect creating the conditions for severe financial imbalances. This concern has led to the promotion of macroprudential

policies that complement the more traditional monetary frameworks. In particular, increased attention to the potential disruptive effects of excessive credit growth has led to a push to design macroprudential policies that seek to smooth out credit cycles (Dell'Ariccia and others, 2012). Along these lines, many countries have adapted their supervisory and regulatory frameworks to introduce countercyclical provisioning, among other actions. It is quite conceivable that, in tandem, central banks have broadened their focus to include financial stability concerns and that credit growth is being monitored and incorporated into monetary policy decisions as well.

Agénor and Pereira da Silva (2013) promote the idea that central banks should institute an integrated inflation-targeting (IIT) framework that, among other features, allows for the possibility that, in setting their policy rates, central banks should consider not only the output and inflation gaps but also variables that may signal future financial instability. One such variable is the rate of growth of credit, whose inclusion in the reaction function can be derived from an optimization problem—the minimization of a policy loss function that explicitly takes into account a financial stability objective—in which expectations with regard to asset prices depend on credit growth.[11] A second additional variable is the exchange rate or, more specifically, a measure of exchange rate misalignment. The introduction of an exchange rate variable in the augmented Taylor rule was considered by Taylor himself on account of its possible effect on inflation and output (Taylor, 2001). The exchange rate was also incorporated in the inflation-targeting policy rule for open economies proposed by Svensson (2000). However, the IIT framework that we discuss here includes an exchange rate variable not only on account of its impact on aggregate demand but also on account of its implications for financial sustainability, which can be related to the negative wealth effects of a currency depreciation when there are high levels of liability dollarization (as in Calvo and Reinhart, 2002) or on account of the Dutch disease effects of an appreciation (as in Levy-Yeyati and Sturzenegger, 2001).[12]

11. Recent theoretical work shows how central banks might operationalize the use of financial stability indicators in their reaction function; see Woodford (2012). See also Agénor and Pereira da Silva (2012) and Disyatat (2010).

12. See Aizenman, Hutchinson, and Noy (2011) for a policy reaction function in which the loss function incorporates concerns with regard to the volatility of the exchange rate. See Roger, Restrepo, and García (2009).

Evidently, there are serious challenges in implementing IIT, including prominently the fact that credibility is a central element of any inflation-targeting framework, and credibility could be compromised with a proliferation of goals pursued by the central bank. While IIT can be understood as a policy proposal for the future, it is worth asking whether or not there is evidence that the countries in our sample—which certainly did not experience the kinds of financial sector disruptions that characterized more mature economies—were in fact operating as if under an IIT framework in the recent past. While it is evident that many macroprudential policies had been put in place well ahead of the 2008 financial crisis in the countries under study, an additional issue worth exploring has to do with the possibility that, in practice, an expanded Taylor rule was also in place.

We therefore turn to the estimating equation 2, a specification in which a vector of additional variables *Wt* is incorporated to reflect the central bank's possible response to the exchange rate and to credit growth. In particular, with regard to the exchange rate, we test for the possibility that the policy rate may respond to deviations of the real exchange rate from its HP trend ($RER_d hp$). This variable provides an easily observable and measurable proxy for exchange rate misalignment. We also test whether there is a response of the policy rate to the real credit gap *C* as a proxy for signals regarding financial stability.[13] OLS estimations are reported in tables 9 and 10. It is quite evident from the results that, whatever its merits going forward, there is little evidence in the data that the countries in our sample have been following an IIT framework in which variables other than output and inflation gaps play a role in the determination of the policy rate. In particular, in none of the countries is there a significant response either to the deviation from trend in the real exchange rate or to the deviation from trend in the real credit gap.

Interestingly, we obtain similar results using the Markov switching procedure for the same specification, as reported in table 11 (short-term coefficients) and table 12 (long-term coefficients). Again, all four countries spend most of the time in regime 1. For this case, the misalignment of the real exchange rate has a positive and significant effect on the policy rate in the case of Colombia, while the credit gap is positive and significant in the case of Chile. Nevertheless, these coefficients are only marginally relevant in eco-

13. In terms of the variable definitions in table 1, we report the results for estimations using as an explanatory variable *C*1, the difference between the growth of real credit and real GDP. This measure yielded stronger results than the two alternatives, *C*2 (the credit-to-GDP ratio) and *C*3 (the ratio of nonperforming loans to total loans).

TABLE 9. Integrated Inflation Targeting, Short-Term OLS Estimations[a]

Description	*Brazil*	*Chile*	*Colombia*	*Peru*
Intercept	0.48**	0.37***	0.21**	0.40***
	(0.03)	(0.00)	(0.01)	(0.00)
$\sum_{0}^{4} i_{t-1}$	0.89***	0.91***	0.95***	1.2***
	(0.00)	(0.00)	(0.00)	(0.00)
x_t	0.07***	0.05***	0.03***	0.12***
	(0.01)	(0.00)	(0.00)	(0.00)
π^1	0.04	0.21***	0.15**	0.02
	(0.33)	(0.00)	(0.02)	(0.66)
$RER_d hp$	0.008	0.004	0.004	0.007
	(0.15)	(0.55)	(0.35)	(0.22)
$C1$	−0.001	0.003	−0.003	0.007
	(0.16)	(0.71)	(0.25)	(0.22)
R^2	0.97	0.94	0.97	0.94
Observations	152	152	152	130
D-W test (χ^2)	0.16	0.02	0.59	0.67
	(0.69)	(0.89)	(0.44)	(0.75)

Source: Authors' calculations.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
a. *p*-values in parentheses.

nomic terms. As an example, while in the short run for Colombia an increase of 1 percent in the output gap brings about a 0.04 percent increase in the policy rate, this same response for the real exchange misalignment is only 0.006 percent. Thus there does not seem to be support for a widespread IIT framework operating in these countries.[14] Finally, once again in all four cases none of the parameters are significant in regime 2.[15] Thus regime 2 again corresponds to a sporadic and short-lived abandonment of the normal reaction function.

Determinants of Central Bank Intervention in the Foreign Exchange Market

Although the previous section provides evidence that in most cases the central bank apparently has not taken exchange rate considerations into account when setting interest rates, it is plausible that the countries analyzed have, at

14. These results are robust to different definitions of the "credit" variable (Barajas and others, 2014).

15. Importantly, this result also holds in estimations in which additional explanatory variables such as the EMBI and the VIX volatility index were considered in the estimation (Barajas and others, 2014).

TABLE 10. Integrated Inflation Targeting, Long-Term OLS Estimations

Description	*Brazil*	*Chile*	*Colombia*	*Peru*[a]
x_t	0.63***	0.55***	0.6***	n.c.
π^1	0.36	2.33***	3.2**	n.c.
$RER_d hp$	0.007	0.04	0.08	n.c.
$C1$	−0.009	0.03	−0.06	n.c.

Source: Authors' calculations.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
a. Since the lagged coefficient of the interest rate is greater than 1, there are no meaningful long-term coefficients in the case of Peru.

TABLE 11. Integrated Inflation Targeting, Short-Term Markov Switching Estimations[a]

	Brazil Regime		*Chile Regime*		*Colombia Regime*		*Peru Regime*	
Description	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*
Intercept	0.46**	0.93	0.24***	0.28	0.18***	−0.36	0.17***	−1.05
	(0.03)	(0.97)	(0.00)	(0.95)	(0.00)	(1.00)	(0.00)	(1.00)
$\sum_0^4 i_{t-1}$	0.91***	0.88**	0.95***	0.8	0.93***	0.94***	1.2***	0.71
	(0.00)	(1.00)	(0.00)	(0.37)	(0.00)	(0.00)	(0.00)	(0.46)
x_t	0.07**	−0.26	0.03***	−0.08	0.04***	0.04	0.03**	0.17
	(0.03)	(1.00)	(0.00)	(0.97)	(0.00)	(0.88)	(0.01)	(0.64)
π^1	0.03	−0.13	0.09	−0.26	0.16***	−0.12	0.04*	0.18
	(0.35)	(1.00)	(1.00)	(0.86)	(0.00)	(1.00)	(0.07)	(0.96)
$RER_d hpt$	0.008	0.09	0.001	−0.01	0.006*	0.005	0.002	−0.07
	(0.14)	(0.99)	(0.62)	(0.97)	(0.07)	(0.93)	(0.69)	(0.931)
$C1$	−0.01	0.003	0.004*	−0.01	−0.0002	0.005	0.002	−0.02
	(0.17)	(1.00)	(0.05)	(0.99)	(0.92)	(0.95)	(0.22)	(0.94)
$\sigma^s t$	0.22***	0.00	0.01***	20.4	0.02***	0.61	0.01***	4.01
	(0.00)	(1.00)	(0.00)	(1.00)	(0.00)	(1.00)	(0.00)	(1.00)
$p = p11$	1.00***		0.97***		0.98***		0.96***	
	(0.00)		(0.00)		(0.00)		(0.00)	
L	−102.53		28.88		7.89		59.34	

Source: Authors' calculations.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
a. p-values in parentheses. L is the value of the log likelihood function. Furthermore, the probability ($p = P11$) of staying in regime 1, given that the economy is in the same state at time ($t-1$). σ is the model's variance.

TABLE 12. Integrated Inflation Targeting, Long-Term Markov Switching Estimations, Regime 1[a]

Description	*Brazil*	*Chile*	*Colombia*	*Peru*
x_t	0.77***	0.6***	0.6***	0.15***
π^1	0.33	1.8	2.2***	0.2*
$RER_d hp$	0.09	0.02	0.08*	0.1
$C1$	−0.11	0.08*	−0.002	0.1

Source: Authors' calculations.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
a. p-values in parentheses.

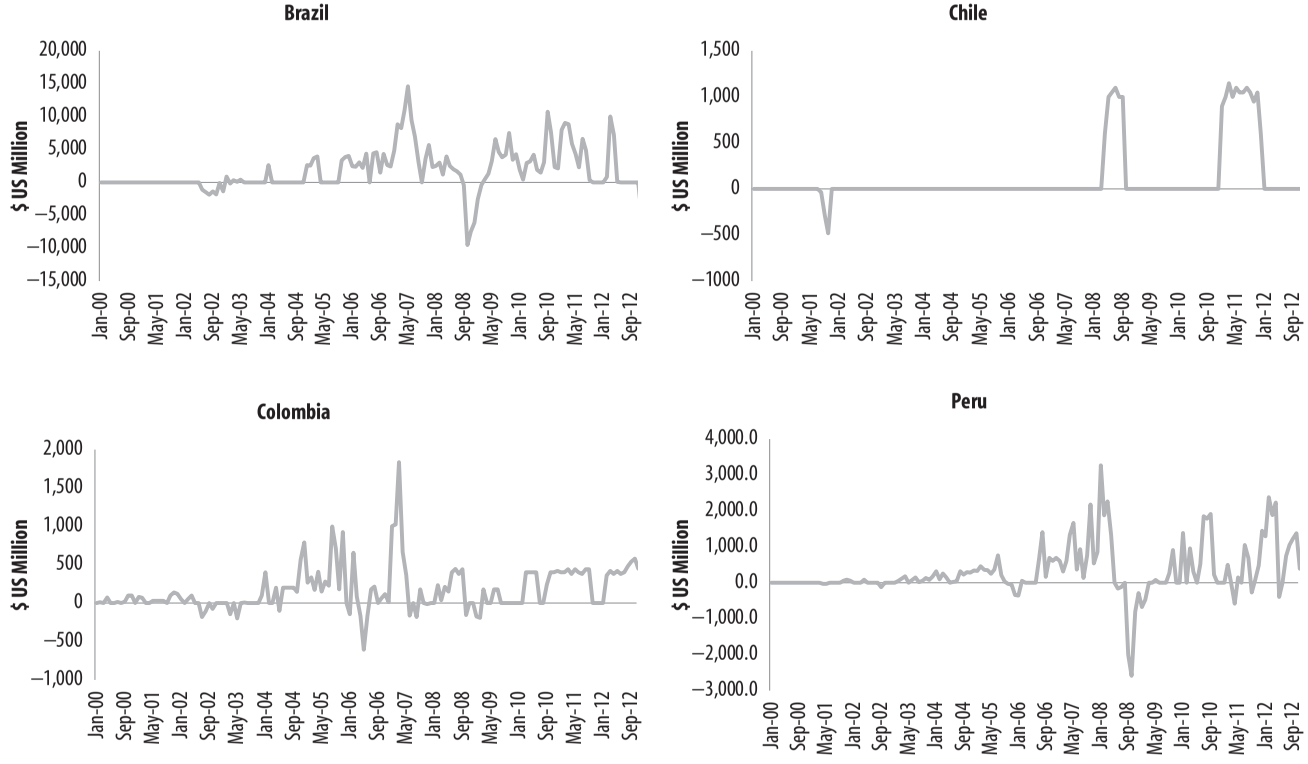
one time or another, intervened directly in the forex market to target a certain level of the exchange rate or to moderate extreme fluctuations. After all, the region has had a justifiable history of concern both over potential Dutch disease effects of large terms of trade shocks and over the potential destabilizing effects of sizable inflows and outflows of foreign capital. Thus even under inflation targeting, one might expect some degree of exchange rate targeting, especially in the face of large external shocks.[16]

Interestingly, central banks consistently argue that, if and when they intervene in the forex market, they do so either as a prudential measure to replenish international reserves or on account of concerns about exchange rate volatility. For all four countries we have thoroughly reviewed the minutes of the monetary policy committee and the inflation reports—and in the case of Colombia reports to congress as well. With the notable exception of a 2003 statement by the Banco de la República de Colombia, according to which the sale of reserves in 2003 was prompted by the need to reduce inflationary pressures coming from the evolution of tradable goods prices, to the best of our knowledge there is no mention of concerns with the *level* of the exchange rate as a motive for central bank intervention in the forex market. The Peruvian authorities claim to intervene on the basis of two objectives: to improve the level of net international reserves (NIR) and to control exchange rate volatility. Based on its inflation reports, the central bank intervened in the forex markets to alleviate real exchange rate volatility during the market uncertainty of 2002 and just after the Lehman Brothers crisis. In the case of Chile, in addition to these two objectives, reference is made to the stabilization of financial markets, especially during the Lehman Brothers crisis, when the central bank decided to introduce a set of unconventional measures. Interestingly, the central bank of Brazil provides no explanation for its intervention in the forex market. This is in line with Chang (2007, 32), according to whom, "in contrast to the other cases discussed in this paper, the Banco Central do Brasil has refrained from any explicit claims to any 'right to intervene' in the foreign exchange market."

In what follows we show how large these interventions have been and then identify their determinants. In figure 2 we report monthly data on net central bank purchases of foreign exchange (purchases minus sales), *FCL*. From the figure it is quite evident that intervention was not very large or

16. Capital markets appear to recognize the advantages of intervention; one empirical study shows that, regardless of the stated or de jure regime, emerging economies displaying greater intervention are rewarded in the form of lower sovereign spreads (Barajas, Erickson, and Steiner, 2008).

FIGURE 2. Net Foreign Exchange Purchases by the Central Bank



Source: The series for Peru, Colombia, and Chile from central bank data. Brazil data kindly provided by BTG Pactual.

common at the beginning of inflation targeting, a behavior consistent with the view expressed in Barajas, Erickson, and Steiner (2008) in the sense that, in the initial years of the inflation-targeting regime, central banks were particularly concerned with establishing and consolidating credibility in a monetary regime that, in its purest form, calls for a floating exchange rate regime.[17]

A salient feature of figure 3 is that most interventions have been on the upside, in order to purchase NIR. Regardless of the motive for doing so, central banks in our sample have almost consistently built up their NIR stocks, which is consistent with the NIR replenishment motive frequently argued by monetary authorities. Finally, note that in the case of Chile interventions were relatively rare occurrences—only three discrete instances during our sample period—and tended to be decided well in advance. For example, as described by the Bank for International Settlements (2013), the two interventions taking place in the last five years shared the same strategy of preannounced programs of purchases of foreign exchange for a period of one year each. Indeed, the total amount of reserves to be bought was explicitly stated in the two cases. Similarly, the amount of daily purchases was determined previously, and the only degree of freedom the central bank kept was to decide the date of the auction.

Following Levy-Yeyati and Sturzenegger (2001) and Barajas, Erickson, and Steiner (2008), we also construct the following intervention index (*INTERV*) to get a better feeling for the relative magnitude of forex intervention:

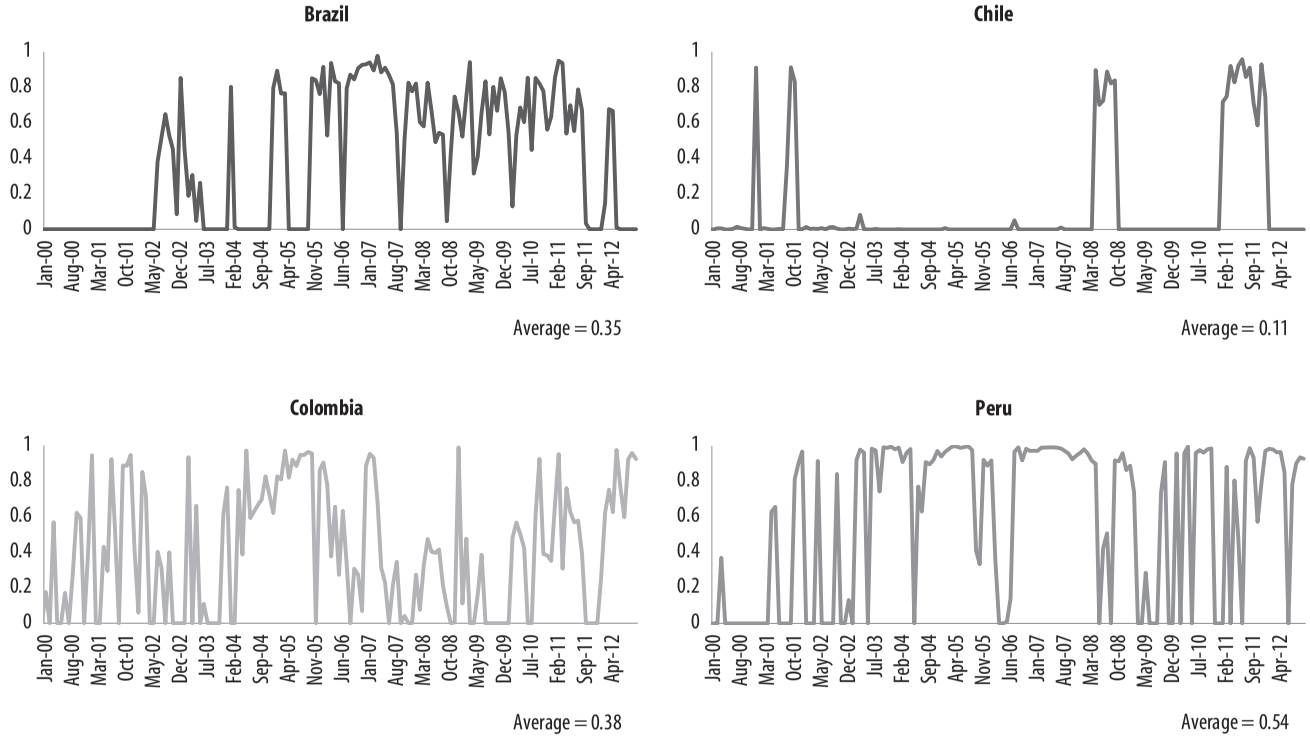
$$INTERV_t = \frac{\left|FCL_t e_t / BM_{t-1}\right|}{\left|\Delta E_t / E_{t-1}\right| + \left|FCI_t e_t / BM_{t-1}\right|},$$

where *FCL* is central bank purchases and sales in the forex market (figure 3, in U.S. dollars), *BM* is base money, and *e* is the nominal U.S. dollar exchange rate.[18] The numerator measures monthly *FCL* expressed in domestic currency

17. A caveat is in order. In this paper we analyze only forex intervention by central banks, although intervention may at times take place through sovereign wealth funds.

18. Prior estimations of *INTERV* have generally used changes in NIR instead of purchases and sales in the forex market. That approach is problematic for many reasons, including the fact that, because of valuation issues, international reserves can change (in U.S. dollar terms) even if no forex market intervention has taken place. Likewise, reserves may increase as a consequence of the interest payments received on account of their investment. In the country data appendix, we report the exact definition and source of purchases and sales.

FIGURE 3. Intervention Index



Source: Authors' calculations.

and scaled by the previous end-month base money stock. In a country with a pure exchange rate float, in which *FCL* is zero, the index will be zero. In case of a fixed exchange rate, *INTERV* equals one. Also note that *INTERV* is always positive, making no distinction between purchases or sales of the same magnitude.

Figure 3 shows *INTERV* for Brazil, Chile, Colombia, and Peru, from January 2000 to September 2012. Four aspects are worth highlighting:

—All four countries intervene, and quite substantially at times.

—The monthly average of *INTERV* suggests that Peru (at 0.54) is the country that intervenes the most and Chile the least (0.107), with Brazil (0.35) and Colombia (0.38) somewhere in between.

—With the exception of Chile, the other countries intervene quite often.

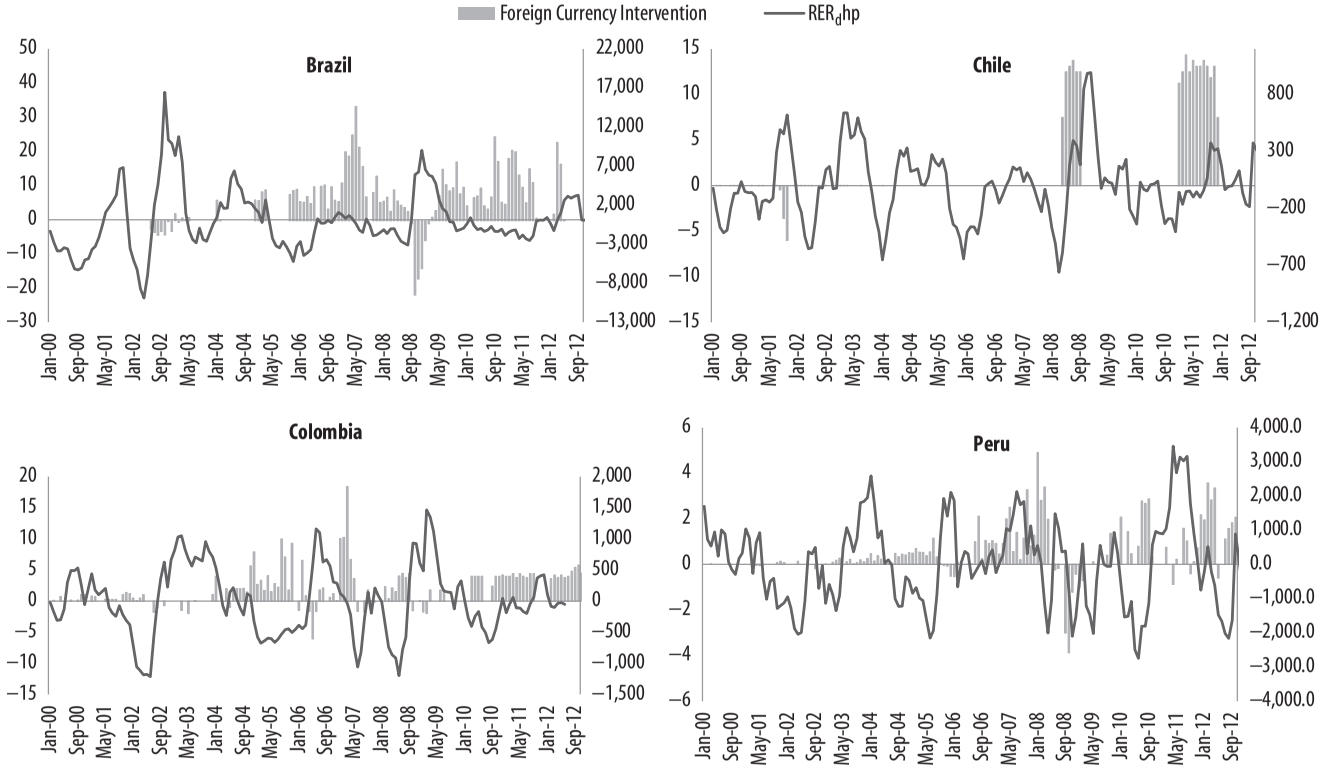
—In all four countries there are instances in which the exchange rate regime behaves as if it were a fixed exchange rate, with the intervention index approaching unity.

Figure 4 reports two series for each country: one, *FCL* net foreign currency purchases; and $RER_d hp$, the deviations of the *RER* from its *HP* trend. A positive value for this variable indicates that the *RER* is weaker (more depreciated) than its long-run trend level, while a negative deviation indicates the relative strength of the domestic currency. Deviations in *RER* are measured in percentage terms on the left-hand axis and, by definition, average to 0. *FCL* is measured on the right-hand axis (in US$ million). Figure 4 supports two stylized facts. First, in almost all cases there is a visible asymmetry, as central banks purchased reserves more aggressively when the currency was strong in comparison to selling reserves when it was weak. Two, there is no general coincidence among countries in the periods of large interventions. While Brazil and Peru undertook their largest sales in the forex market during the Lehman episode, the central banks of Colombia and Chile rarely intervened.

This analysis of intervention in the forex market allows us to answer several questions. Does intervention respond to perceived real exchange rate misalignments? If so, is the response symmetric, treating depreciations and appreciations similarly? Does intervention respond to exchange rate volatility? Is there evidence that forex intervention depends on the level of international reserves?

In what follows we explore the possible determinants of *FCL,* a variable that can be positive (net reserve purchases by the central bank) or negative (net sales). In particular, we want to determine whether forex interventions are explained by exchange rate volatility or accumulation of reserves (as is usually argued by central bankers) or if concerns with regard to exchange rate

FIGURE 4. Central Bank Net Foreign Purchases and the RER Gap



Source: Authors' calculations. The series was originally taken from central bank data. Brazil data generously provided by BTG Pactual.

levels matter. In particular, we estimate the following "reaction function" for interventions in the foreign currency market:

$$(3) \qquad FCL_t = \theta + \gamma_1(RER_d hp) + \gamma_2(D_1 * RER_d hp)_t + \gamma_3(RER_d hp * RER\sigma^2) + \gamma_4(RER_d hp * NIR) + \gamma_5(RER\sigma^2) + \gamma_6(NIR) + \varepsilon_t.$$[19]

We consider several explanatory variables for *FCL*. First, $RER_d hp$ is as a proxy for real exchange rate misalignment that will allow us to determine whether interventions depend on the *level* of the exchange rate. Second, we allow for an asymmetric response, depending on whether the currency is relatively strong or weak. For this purpose, we interact $RER_d hp$ with a dummy variable D_1 (equal to 1 when $RER_d hp$ is below trend—that is, relatively strong—and equal to 0 when it is above trend—that is, relatively weak). Third, we want to assess the possible importance of exchange rate volatility as a determinant of central bank intervention in the forex market. With that purpose in mind, we include the interaction between $RER_d hp$ and $RER\sigma^2$ (the six-month rolling variance of the real exchange rate) to test if central banks intervened more forcefully when volatility was higher. Fourth, we include the interaction between *NIR* (the level of net international reserves normalized by *M*3) and $RER_d hp$ to uncover the relationship between foreign currency net purchases and the level of *NIR*. Finally, we include the level of each variable independently.

There is a potential endogeneity problem to the extent that the exchange rate could depend on forex intervention itself. We therefore undertake a 2SLS estimation procedure; we sought instruments that would behave as exogenous shocks to the country's balance of payments, thereby affecting the real exchange rate, and that only through this channel would induce a reaction in forex intervention. Our initial candidates were the U.S. federal funds rate and the *VIX* volatility index to reflect opportunity costs affecting capital flows; the EMBI index for country-specific risk; and the terms of trade as an exogenous shifter of the current account. In each country we narrowed the set of instruments to those whose predictive power was verified through a first-stage regression (table 13).[20]

19. In appendix E we report the OLS estimation of equation 3.

20. For *NIR* and $RER\sigma^2$ we use their lags as instruments. For Peru the only valid instrument was the U.S. federal funds rate, which has the drawback that it might affect intervention through an alternative channel, the return on international reserves. We assume that this effect is relatively secondary and that intervention is driven primarily by large movements in capital flows, which exert upward or downward pressure on the real exchange rate. In particular, we first run a regression of the level of *RER* misalignment as a function of the instruments in order to validate the latter. The second stage is performed using as explanatory variables the estimated values obtained in the first stage.

TABLE 13. Determinants of Forex Intervention, Brazil, Colombia, Peru, First Stage[a]

	1.1	*1.2*	*1.3*
Description	*Brazil*	*Colombia*	*Peru*
VIX	…	0.22**	…
		(0.01)	
EMBI	0.008***	…	…
	(0.00)		
i FED	…	…	0.16***
			(0.00)
R^2	0.32	0.28	0.33
Observations	153	153	153

Source: Authors' calculations.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
a. The dependent variable is $RER_d hp$; p-values in parentheses.

The second-stage regressions, reported in table 14, yield several results.[21] First, in Brazil, Colombia, and Peru deviations from trend in the *RER* are significant determinants of interventions in the forex market. When the domestic currency is relatively weak (strong), the central bank intervenes by selling (purchasing) foreign currency. Second, this intervention is asymmetric in Colombia and Peru—the coefficient for $D_1 * RER_d hp$ is negative and significant, showing that interventions that respond to the relative strength of the domestic currency are more pronounced than those for relative weakness. Third, in Colombia and Peru lagged exchange rate volatility does not appear to influence intervention, while in Brazil volatility is associated with a greater propensity to sell foreign currency, while the interaction term seems to imply the opposite, that for a given real exchange rate gap, intervention would tend to be less pronounced as volatility increases. Fourth, in Colombia and Peru sales of foreign currency tend to be greater as the level of international reserves increases, and in the case of Colombia interventions responding to real exchange rate gaps tend to be smaller as the level of reserves increases. These last results provide evidence consistent with, if not an outright reserve target, at least the notion that the level of reserves is taken into consideration when deciding when and by how much to intervene. Contrary to state-

21. Given the relatively few intervention episodes during our sample period, we do not feel confident reporting the estimation results for Chile, although forex interventions did behave similarly to the cases of Colombia and Peru, responding significantly to the real exchange rate gap and exhibiting asymmetry in this response.

TABLE 14. Determinants of Intervention in the Forex Market, Second-Stage Regression Results[a]

		1.1	*1.2*	*1.3*
Description		*Brazil*	*Colombia*	*Peru*
Intercept	…	1445.4	547.1***	41061**
		(0.39)	(0.00)	(0.01)
$RER_d hp$	*RER* deviations from trend	−1075.3**	−41.2*	−50048**
		(0.03)	(0.07)	(0.02)
$D_1 * RER_d hp$	Negative *RER* deviations from trend (currency too strong)	−101.5	−65.9**	−51916.9**
		(0.31)	(0.02)	(0.02)
$RER_d hp * RER\sigma^2$	*RER* deviations from trend interacted with volatility	3.89***	1.14	0.19
		(0.00)	(0.22)	(0.86)
$RER_d hp * NIR$	*RER* deviations interacted with *NIR/M*3	33.4	5.48*	22.2
		(0.25)	(0.07)	(0.59)
$RER\sigma^2$	Volatility	−35.2***	−4.7	1.43
		(0.00)	(0.10)	(0.65)
NIR	*NIR* level normalized by *M*3	26.2	−11.4***	−30.2*
		(0.75)	(0.00)	(0.06)

Source: Authors' calculations.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
a. The dependent variable is *FCL*; *p*-values in parentheses.

ments from all central banks, table 14 suggests that intervention in the forex market is not guided by *RER* volatility alone, and that volatility may not even play a significant part in two of the countries.

One drawback of the previous regression is that the coefficient of *RER* volatility is difficult to interpret. If volatility increases, should the central bank purchase or sell foreign exchange? To address this problem, we also estimated a version of this equation in which the dependent variable is *INTERV,* as described above. In this case, more intervention—regardless of whether it constitutes purchases or sales—is associated with an increase in the index. We test whether the intervention index changes in response to exchange rate volatility, $RER\sigma^2$.[22] As controls we include the real exchange rate gap as well as its interaction with volatility. Results of estimating equation 4 are reported in table 15.

$$(4) \quad INTERV_t = \theta + \gamma_5 (RER\sigma^2)_t + \gamma_2 (RER_d hp * RER\sigma^2)_t + \gamma_1 (RER_d hp)_t + \varepsilon_t .$$

22. These results are robust to different definitions of the volatility variables (see Barajas and others, 2014).

TABLE 15. Intervention Index and Volatility, OLS[a]

Description		*1.1* *Brazil*	*1.2* *Colombia*	*1.3* *Peru*
Intercept		0.54***	0.44***	0.54***
		(0.00)	(0.00)	(0.00)
$RER\sigma^2$	Volatility	0.0002	−0.007**	0.0005
		(0.59)	(0.02)	(0.42)
$RER_d hp$	*RER* deviations from trend	−0.064	−0.08**	−0.07
		(0.53)	(0.00)	(0.51)
$RER_d hp * RER\sigma^2$	*RER* deviations from trend interacted with volatility	−0.00004	0.002**	0.000005
		(0.83)	(0.05)	(0.94)

Source: Authors' calculations.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
a. The dependent variable is *INTERV*; *p*-values in parentheses.

The results do not support the common claim that foreign exchange intervention is undertaken in order to reduce volatility. *RER* volatility is not a significant predictor of intervention in Brazil and Peru, and in Colombia it does so but not with the expected sign. However, in Colombia volatility does interact positively with the real exchange rate gap, in the sense that the larger the real exchange rate gap, the more likely that increased volatility will trigger greater intervention.[23] Finally, note that the real exchange rate gap loses significance, possibly in part because this specification cannot capture the observed asymmetric response to positive versus negative gaps.

Summary and Conclusions

As more and more central banks in emerging economies adopt inflation targeting, and particularly in the aftermath of the global financial crisis, there is growing recognition that a certain amount of flexibility is warranted in implementing these frameworks. On the one hand, although inflation-targeting adoption presupposes a move toward greater exchange rate flexibility, there is a case for counteracting some portion of exchange rate movements to limit pass-through into domestic prices, output costs, loss of competitiveness, or adverse balance-sheet effects. Furthermore, concerns have also arisen with regard to financial stability. Indeed, many observers believe that the recent

23. One could also interpret the interaction in the following manner: for a given real exchange rate gap, intervention will tend to be greater if the exchange rate has exhibited greater volatility in the recent past.

global financial crisis was partially determined by the complacency that came about after years of low and stable inflation. With consumer price index inflation very much under control, monetary policy was loosened. In the context of severe weaknesses in financial supervision and regulation, this looseness set the stage for severe misalignments in key asset prices, most prominently of real estate and in the stock market. Policy prescriptions following the financial crisis include the use of macroprudential measures and possibly even the incorporation of a "private credit gap" measure in the monetary reaction function of central banks.

In short, there are strong arguments in favor of implementing a flexible version of inflation targeting, one that contains some degree of fear of floating together with sensitivity to financial stability concerns. Such an approach can be termed an "extended" or "integrated" approach, as proposed by Agénor and Pereira da Silva (2013). Of course, a key (and as yet unanswered) question is how far such flexibility can be pushed before it undermines credibility, the very foundation of a successful inflation-targeting regime. Some studies surveyed in this paper have then sought to assess how much flexibility has actually been present in countries so far, during periods in which there has been broad success in stabilizing inflation. Indeed, there is evidence of flexibility; monetary reaction functions estimated for various countries show a response to both exchange rate fluctuations and to credit aggregates, while separate panel data analysis shows that forex intervention has been alive and well in inflation-targeting countries.

In this paper we focus on the practice of monetary policy in four early inflation-targeting adopters in Latin America: Brazil, Chile, Colombia, and Peru. Our sample period, 2000–12, encompasses virtually their entire experience with inflation targeting. By focusing on individual country cases rather than on panel data, and by adopting a flexible econometric methodology, we are able to capture cross-country heterogeneity as well as any structural shifts that may have occurred.

Our first analytical exercise focuses on the central bank policy reaction function, using a Markov switching methodology that allows the data to speak for themselves in terms of identifying possible structural breaks. We find that the policy rule was quite stable; departures were infrequent, most often in response to large external shocks such as the 2001–02 period of heightened risk aversion toward emerging markets and the 2008–09 global turmoil unleashed by the collapse of Lehman Brothers. In the case of Brazil, the policy rule was even more stable, as it was impossible to detect a meaningful departure from it. We also find evidence that the policy rate in Colombia responded, albeit rather weakly, to a real exchange rate gap, measured by the deviation in the real effective exchange

rate from its trend. In Chile it also responded in a limited way to a private credit gap, measured as the excess growth of credit over that of output. The Markov switching methodology did not detect major shifts in credibility, which might have turned up as regimes characterized by their differing degrees of response to the inflation gap. On the one hand, this is surprising, given that one might have expected credibility gains to be accrued as the inflation-targeting experiences matured. On the other hand, it is encouraging that we did not detect a credibility loss stemming from the greater flexibility and even sporadic abandonments of the rule. As for the departures from the dominant regime, the behavior was not systematic—no rule could be discerned—but it generally implied a loosening in relation to what the conventional rule would have warranted.

In our second exercise, we analyze the determinants of central bank forex intervention. We find strong evidence that, contrary to official central bank statements, intervention seems to be explained to a great extent by concerns with regard to levels of exchange rate misalignments rather than concerns with exchange rate volatility. We also find evidence that, with the exception of Brazil, countries intervene more aggressively when they perceive the currency to be strong than when they perceive the currency to be weak. That is, fear of appreciation is greater than fear of depreciation. Moreover, forex intervention in general seems to be related neither to exchange rate volatility nor to the level of international reserves.

In all, we provide evidence that central banks appear to have pursued two distinct objectives with two different instruments: an inflation objective using mostly the standard Taylor rule—except in Colombia, where the exchange rate gap plays a small role, and in Chile, where it also responded in a limited way to a private credit gap—and an exchange rate objective through interventions in the forex market. At least to date, there does not seem to have been inconsistency in the pursuance of these two objectives, in terms of a visible loss of credibility. Thus, although forex interventions reflect a fear of floating, as emphasized by Reinhart (2013), this has not implied a relaxation of the commitment to low and stable inflation. That is, authorities have not said goodbye to either fear of floating or inflation targeting, so far.

Appendix A. Variables for Brazil

—*SELIC*: short-term rate last day of the month (from the central bank).

—x_t: output gap, or percent deviation of real output from trend. Real output, *Y,* is the monthly GDP (accumulated in the last twelve months) at constant

2008 prices (from the central bank and seasonally adjusted by authors).[24] The trend, Y^*, comes from a conventional *HP* estimation.

—$E_t\pi_{t+1}$: expectations (from the monthly consensus forecast by Latin Focus consensus forecast).[25]

—π_t^T: inflation target announced by the central bank (from "Histórico de Metas para a Inflação no Brazil").

—π_t: inflation corresponding to the annual variation from the consumer price index (original series from the central bank).

—$RER_d hp_t$ $(RER - RER\ hp/RER\ hp)^{rer_{hp}}$: authors' estimations of percent deviations of the real exchange rate (*HP*) trend (*RER* from the central bank, which uses the consumer price index as deflator and comprises the ten main trading partners).

—*RER* σ_t^2: six-month rolling variance of the real exchange rate (authors' calculations).

—$C1_t\left(\frac{\partial RC}{RC} - \frac{\partial Y_t}{Y_t}\right)$: credit growth with respect to the same month of the previous year, deflated by changes in the consumer price index and defined as the gross loan series (from the central bank). Real output is Y_t growth with respect to the same month of the previous year.

—$C2_t$ (*RC/GDP*): credit defined as the gross loan series and in real terms (from the central bank). Real output is Y_t.

—$C3_t$: nonperforming loans over the gross loan series in real terms (from the central bank).

—FCL_t: foreign currency intervention (from "Intervenções do Banco Central"). This information includes regular spot intervention and all other varieties except derivatives. It includes forward sales and purchases, means repos, lending of foreign currency by the central bank to domestic (financial) counterparties, and lending of foreign currency by the central bank earmarked for lending as export financing (data from BTG Pactual).

—*EMBI and NIR*: (from the central bank) EMBI calculated by JPMorgan Chase.

24. To seasonally adjust the series we used the Tramo-seats methodology, which incorporates ARIMA model-based signal extraction techniques.

25. This is the longest inflation expectations survey available. Unfortunately, it only includes expectations for end December of the current and of the following year. We have decided to establish the month of April as the cutoff point: expectations for January–March of year *t* are those of December year *t,* whereas expectations for April–December of year *t* are those of December year $t + 1$. The procedure was followed for the expectation series of all four countries.

Appendix B. Variables for Chile

—i_t: short-term repo rate, first of the month (from the central bank).

—$i_{j,t-1}$: lag for one period of the j-th short-term repo rate.

—x_t: output gap measured as percent deviations of real output from trend. Real output, Y, is the monthly IMACEC (indicador mensual de actividad económica) in 1990 constant prices (from the central bank and seasonally adjusted by the authors; after we obtain the monthly GDP series, the trend, Y^*, comes from a conventional HP estimation).

—$E_t\pi_{t+1}$: inflation expectations (from the monthly consensus forecast by Latin Focus).

—π_t^T: inflation target announced by the central bank (see its inflation reports).

—π_t: inflation corresponds to the annual variation from the consumer price index (original series from the central bank).

—$RER_d hp_t$ ($RER - RER\ hp/RER\ hp$): authors' calculations of percent deviations of the real exchange rate from its (HP) trend (real exchange rate from central bank data). This variable includes twenty-one main trading partners, deflated by the consumer price index.

—$RER\ \sigma^2$: six-month rolling variance of the real exchange rate (authors' calculations).

—$C1_t$ ($\partial RC/RC - \partial Y_t/Y_t$): credit growth with respect to the same month of the previous year, deflated by changes in the consumer price index and defined by the gross loan series (from Superintendencia de Bancos e Instituciones Financieras). Real output Y_t growth with respect to the same month of the previous year.

—$C2_t$ (RC/GDP): credit defined by the gross loan series (from Superintendencia de Bancos e Instituciones Financieras). Real output is the GDP monthly calculation based on the methodology proposed by Litterman (1983).[26]

—$C3_t$ (*nonperforming loans*/RC): these loans over the gross loan in real terms series (from Superintendencia de Bancos e Instituciones Financieras).

—FCL_t: foreign currency intervention series, "Activos de reservas internacionales" component "Operaciones de cambio con banco" (from central bank).

26. In this methodology we transform the annual series of the GDP obtained in the Banco Central de Chile to a monthly series.

—*VIX*: index of implied volatility in the U.S. stock market, derived from prices of options on the S&P 500 index (from Bancolombia; original series comes from Bloomberg).

—*Terms of trade*: quarterly IMF data converted to monthly based on Litterman (1983).

Appendix C. Variables for Colombia

—i_t: short-term repo rate, first of the month (from the central bank).

—$i_{j,t-1}$: lag for one period of the *j*-th short-term repo rate.

—x_t: output gap measured as the percent deviation of real output from trend. Real output, *Y,* is the monthly IPIR (Indice de Producción Industrial) (from the central bank) at 1990 constant prices and seasonally adjusted by the authors. After we obtain the monthly GDP series, the trend, *Y**, comes from a conventional *HP* estimation.[27]

—$E_t\pi_{t+1}$: inflation expectations (from the monthly consensus forecast by Latin Focus).

—π_t^T: inflation target announced by the Banco de la República (from its reports to congress).

—π_t: inflation corresponding to the annual variation from the consumer price index (original series from the central bank).

—$RER_a hp_t$ ($RER - RER\ hp/RER\ hp$): percent deviations in the real exchange rate from its (*HP*) trend, based on the authors' calculations. Real exchange rate from Banco de la República. This index uses the consumer price index as a deflator and is in reference to the weighted average of the twenty main trading partners.

—$RER\ \sigma^2 t$: six-month rolling variance of the real exchange rate (authors' calculations).

—$C1_t$ ($\partial RC/RC - \partial Y_t/Y_t$): credit growth with respect to the same month of the previous year, deflated by changes in the CPI, and defined as the gross loan (from Superintendencia Financiera de Colombia). Real output Y_t growth with respect to the same month of the previous year.

27. Our output gap measure does not correspond to the theoretical measure found in New Keynesian models of the Woodford-Gali type, which is equal to the difference between output and its flexible price counterpart. According to Cobo (2005), the difference among these approaches for Colombia is marginal in terms of forecasting performance.

—$C2_t$ (*RC*/*GDP*): credit defined as the gross loans (from Superintendencia Financiera de Colombia). Real output is the GDP monthly calculation based on the methodology proposed by Litterman (1983).[28]

—$C3_t$: nonperforming loans over the gross loan in real terms series (from Superintendencia Financiera de Colombia).

—FCL_t: foreign currency intervention series, "Operaciones de Compra: Venta de Divisas del Banco de la República" (without government sales) (from Banco de la República).

—*Terms of trade and* NIR_t: from the Banco de la República.

Appendix D. Variables for Peru

—i_t: interbank rate (from the Banco Central de la Reserva de Perú).

—$i_{j,t-1}$: lag for one period of the *j*-th short-term repo rate.

—x_t: output gap measured as the deviations of real output from trend. Real output, *Y,* is the monthly GDP at constant 2008 prices (from the central bank) (seasonally adjusted by the authors). The trend *Y** from a conventional *HP* estimation.

—$E_t\pi_{t+1}$: inflation expectations (from the monthly consensus forecast by Latin Focus).

—π_t^T: inflation target announced by the central bank (see its inflation reports).

—π_t: inflation corresponds to the annual variation from the consumer price index (original series from the central bank).

—$RER_d hp_t$ (*RER* − *RER hp*/*RER hp*): authors' estimations of the percent deviations in the real exchange rate from its (*HP*) trend. Real exchange rate (from the central bank) uses consumer price index as the deflator and is a weighted average of the twenty main trading partners.

—*RER* σ_t^2: six-month rolling variance of the real exchange rate (authors' calculations).

—$C1_t$ ($\partial RC/RC - \partial Y_t/Y_t$): credit growth with respect to the same month of the previous year, deflated by changes in the consumer price index and defined as the gross loans (from the central bank). Real output, Y_t, growth with respect to the same month of the previous year.

28. In this methodology we transform the annual series of the GDP obtained in the Banco de la República (the primary source is the DANE) to a monthly series.

—$C2_t$ (*dRC*/*GDP*): credit defined as the gross loans (from the central bank). Real output is Y_t.

—$C3_t$: nonperforming loans over the gross loan in real terms series (from the central bank).

—FCL_t: foreign currency intervention series, "Compras (ventas) netas mensuales de dólares en el mercado por parte del Banco Central de Reserva del Perú."

—*FED interest rate*: from Federal Reserve System.

—*NIR t*: from the central bank.

Appendix E. Determinants of Intervention in the Forex Market (OLS)[a]

		1.1	*1.2*	*1.3*
Description		*Brazil*	*Colombia*	*Peru*
Intercept	…	2413.1*	423.9***	1818.8**
		(0.07)	(0.00)	(0.01)
RERdhp	*RER* deviations from trend	−410.9*	−8.3	−48.0
		(0.06)	(0.76)	(0.48)
$D_1 * RER_d hp$	Negative *RER* deviations from trend (currency too strong)	−86.3	−97.7	−25.9
		(0.47)	(0.17)	(0.80)
$RER_d hp * RER\sigma^2$	*RER* deviations from trend interacted with volatility	1.24**	0.21	0.11
		(0.01)	(0.57)	(0.91)
$RER_d hp * NIR$	*RER* deviations interacted with *NIR*/*M*3	−33.2***	0.08	0.25
		(0.00)	(0.90)	(0.90)
$RER\sigma^2$	Volatility	−23.6***	−3.14*	1.11
		(0.00)	(0.06)	(0.72)
NIR	*NIR* level normalized by the *M*3	32.4	−8.8**	−28.8*
		(0.64)	(0.01)	(0.05)

Source: Authors' calculations.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

a. *p*-values in parentheses.

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