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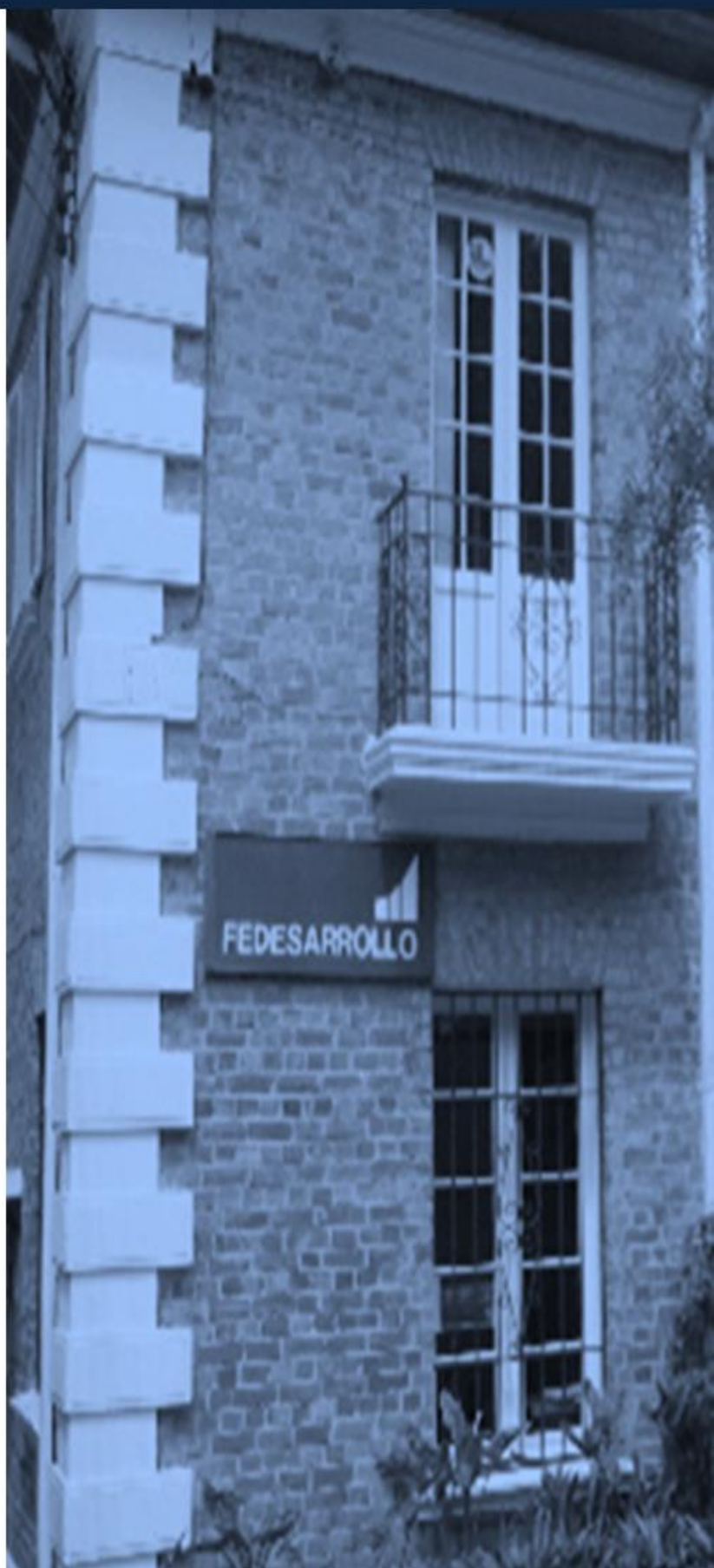
Inflation Targeting in Latin America

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Abstract

We examine how monetary policy has been conducted in four early adopters of Inflation Targeting: Brazil, Chile, Colombia and Peru. First, a Markov-Switching approach shows that while all four countries exhibit considerable stability in their responses to the inflation and output gaps, most have departed from this rule in times of extreme turmoil. We also find evidence of an "extended" or "integrated" IT approach in two countries, the policy rate responding to either a real exchange rate or a private credit gap, the latter possibly indicating financial stability concerns. We do not find evidence of changes in credibility over time. Second, forex intervention is driven primarily by exchange rate misalignments rather than by exchange rate volatility or by an international reserves objective. Such intervention generally responds more strongly to appreciations than to depreciation and does not respond to inflation. Thus, IT in these countries so far can be characterized as flexible, coexisting with a degree of fear of floating and a financial stability objective, either built directly into the policy rule or complemented with macro-prudential measures.

JEL classification: E31; E52; E61
Keywords: Inflation targeting; Markov Switching; Taylor rules; intervention in foreign exchange markets

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Resumen

Examinamos cómo se ha llevado a cabo la política monetaria en los cuatro primeros países en adoptar inflación objetiva: Brasil, Chile, Colombia y Perú. En primer lugar, un enfoque de Markov Switching muestra que si bien los cuatro países presentan una gran estabilidad en sus respuestas a las brechas de inflación y producto, la mayoría han salido de esta regla en tiempos de crisis extrema. También encontramos evidencia de un enfoque de IO "extendida" o "integrado" en dos países, la tasa de política en respuesta a un tipo de cambio real o una brecha de crédito privado, este último posiblemente indicando problemas de estabilidad financiera. No encontramos evidencia de cambios en la credibilidad a través del tiempo. En segundo lugar, la intervención de la divisa es impulsada principalmente por desajustes de los tipos de cambio, en lugar de por la volatilidad del tipo de cambio o por un objetivo de reservas internacionales. Tal intervención generalmente responde con más fuerza a las apreciaciones que las depreciaciones, y no responde a la inflación. Por lo tanto, la IO en estos países hasta el momento se puede caracterizar como flexibles, coexistiendo con un grado de temor a la flotación y un objetivo de estabilidad financiera, ya sea integrado directamente en la regla política o complementarse con medidas macroprudenciales.

Clasificación JEL: E31, E52, E61
Palabras Clave: Inflación objetivo, Markov switching, regla de Taylor, intervención en mercados de cambio extranjeros.

1. Introduction

As in other regions, in the last decade and a half several Latin American countries have adopted inflation targeting (IT) as their monetary framework, moving away from other intermediate targets such as monetary aggregates and allowing, at least on paper, greater flexibility in their exchange rates. While the literature so far has not delivered a clear verdict on the impact of adoption of IT on macroeconomic performance in general—particularly in comparison to other monetary frameworks that have faced the same global environment—it is undeniable that IT countries have generally succeeded in stabilizing inflation at relatively low rates, as well as in anchoring the public's expectations at levels near the intended target ranges[2].

One recurring question that arises in the study of IT throughout the world is the degree of flexibility that policymakers can and should have in implementing these frameworks. Namely, to what extent should exchange rate fluctuations or financial stability concerns also be incorporated into the policy rule of an IT central bank that aims at achieving a pre-announced target for inflation? This is particularly relevant given that IT relies critically on policy credibility and effective communication with the public, thus the perception that multiple—and possibly conflicting—objectives are being pursued might undermine such credibility, thereby endangering the integrity of the policy framework.

Regarding the exchange rate, the question is whether IT can or should accommodate a certain degree of "flear 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 IT central banks should indeed respond to these movements when, via 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, affect competitiveness, and—particularly in highly dollarized economies—lead to substantial balance-sheet effects that ultimately feed into financial instability.

[2] See Agenor and Pereira da Silva (2013) for a comprehensive review of the evidence.

In fact, there is evidence that IT countries have been reacting to exchange rate movements. Estimating a monetary reaction function for a panel for the 1996-2011 period, encompassing both advanced and emerging countries as well as IT and non-IT countries, Muñoz and Schmidt-Hebbel (2012) find that the short-term policy rate in IT countries—similarly to the case in non-IT—reacts to changes in the nominal exchange rate. Using a similar approach, but focusing on emerging economies, Aizenman, *et. al* (2010) find that the policy rate reacts to changes in the real exchange rate, particularly in countries which rely to a large extent on commodity exports. Note that, from both studies it is not possible to determine 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 forex interventions by central bank. Consistent with the presumed greater exchange rate flexibility of IT, they find that exchange rates are indeed more volatile in IT in comparison to non-IT countries. However, forex intervention is far from absent in IT countries, and is found to be effective in reducing exchange rate volatility.

On the second question, whether financial stability concerns should be incorporated into an IT framework, there is also a case for expanding the set of instruments at the disposal of policymakers—making use of macro-prudential 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. Agenor and Pereira da Silva (2013) propose an "Integrated Inflation Targeting" (IIT) framework which addresses both objectives, and which 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. In the above mentioned study, Muñoz and Schmidt-Hebbel (2012) also find evidence that policy rates in IT countries have been responding 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 emerging countries in Latin America—Brazil, Chile, Colombia and Peru—during the 2000-2012 period, covering virtually their entire experience so far with IT. These countries, together with Mexico, constitute the group of original inflation targeting countries in Latin America. We assess in general how they have conducted IT, and in particular how flexible they have been in terms of incorporating a response to exchange rate movements and/or possible financial stability concerns. Contrary to the studies surveyed above, we focus on individual country experiences and adopt a flexible approach that allows us to discern cross-country heterogeneity as well possible structural breaks over time.

We undertake two main analytical exercises. First, we estimate country-specific monetary reaction functions using a Markov-Switching (MS) methodology which can allow us to detect whether observable regime switches have taken place over time in each of the countries. The flexibility offered by this approach allows us to ask several key questions regarding how IT has evolved over time and how flexible it has been. Furthermore, this methodology allows the data to "speak for itself", in the sense that the dates of these shifts are not determined ex ante.

Specifically, the MS approach to the monetary reaction function allows us to ask the following questions, which will shed light on the observed degree of flexibility of IT in these countries: (1) How stable has the policy rule been over time? (2) 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 and/or an increase in the response to other arguments in the reaction function[3]. (3) Has there been "fear of floating", a response to exchange rate movements—either as an indication of pass-through to domestic prices or as a separate objective? (4) Has financial

[3] 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.

stability been incorporated into the reaction function—through a private credit gap measure— particularly in recent years when these countries have introduced a host of macro-prudential measures to complement monetary policy?[4] (5) Related to the previous two questions, has the response to exchange rate or private credit gap been systematic over the entire period, or episodic, arising only in certain, brief periods? (6) 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 or not such intervention is, as claimed by most central banks, entirely driven by concerns with exchange rate volatility or rather there is evidence of a "level" objective for the exchange rate.

This analysis of forex intervention will allow us to ask: (1) Does intervention respond to perceived real exchange rate misalignments and if so, is the response symmetric, treating depreciations and appreciations equally? (2) Does it respond to increases in exchange rate volatility? (3) Is intervention complementary to interest rate policy, in the sense that it also responds to changes in the inflation gap? (4) 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 MS analysis in the four countries shows that monetary reaction functions were remarkably stable throughout. The estimation yielded a dominant regime, applying to more than 90 percent of the observations. In that sense, there was no evidence of an enhancement in credibility, in terms of a regime shift from an initial regime with a relatively strong response to the inflation gap to a posterior regime with a relatively weak response, nor did 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

[4] Barajas *et.al* (2014) provides a description of these macro-prudential measures.

than would have been 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 do so across all countries in an asymmetric fashion, appreciations triggering a stronger intervention than depreciations. Exchange rate volatility only appears to trigger greater intervention in Chile, and we find little evidence that intervention was driven by an effort to increase international reserves. In summary, we find that IT has been flexible in these countries and that this flexibility has been stable over time. The framework has been resilient to domestic and external shocks—allowing for sporadic departures from the "dominant" rule during certain extreme events— and has coexisted with some degree of fear of floating, and in the case of Chile has incorporated financial stability concerns into the reaction function. This, without visibly sacrificing credibility.

2. Characterizing Monetary Policy in Four Latin American Countries

2.1 Estimating Conventional Taylor Rules

At its most basic, a conventional Taylor Rule summarizes the monetary reaction function under IT as follows:

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

That is, 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—i.e., "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 IT 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.

Table 1. Definition of Variables[5]

Policy variable	**Right-hand side variables**	**Name**	**Description**
Policy rate		I	Country policy rate
	Output gap	x_t	$(У - У\,hp) / У\,hp$, where $У\,hp$ is trend GDP obtained from an H-P filter
Inflation	Inflation Gap 1	π^1	Inflation expectations (from Latin Focus Consensus Forecast) minus the inflation target
	Inflation Gap 2	π^2	Inflation (CPI) minus the inflation target
	Inflation Gap 3	π^3	Inflation expectations
	Inflation Gap 4	π^4	Inflation
Exchange rate	Percentage RER deviations from trend	$RER_d hp$	$(RER - RER\,hp) / RER\,hp$, where $RER\,hp$ is trend RER obtained from an H-P filter
	Credit gap	$C1$	$\Delta RC - \Delta x_t$ where RC is real gross loans and x_t is real output gap
	Financial deepening	$C2$	RC/GDP
	Non-performing loans	$C3$	Non-performing Loans/ RC

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 4 countries the repo rate reacts positively and significantly to the output gap, but the response to the inflation gap is positive and significant in all but Peru. Interestingly, the estimated long-term coefficient for the inflation gap is greater than 1 both in Chile and in Colombia, providing evidence that in these two countries' central banks actually increase the real interest rate in response to positive inflation gaps.

[5] Appendixes A-D report the exact definition and source of each variable in each country.

Table 2. Taylor Rule Estimation (OLS): Short-Term Coefficients

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

Source: Authors' calculations.
Note: *p*-values are in the parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. We also undertook this exercise using quarterly data (Barajas *et.al*. 2014). Results consistent with those using monthly data.

Table 3. Taylor Rule Estimation (OLS): Long-Term Coefficients

	Brazil	Chile	Colombia	Peru
x_t	0.89***	0.85*	0.6***	0.05***
π^1	0.78**	3.14***	2.4**	0.03

Source: Authors' calculations.
Note: p-values are in the parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

These results are similar to those obtained in previous studies (Table 4). In general, in Colombia and Chile the repo rate reacts positively and significantly to the output and the inflation gap. Consistently, Chile reports the highest response to inflation gap among the four countries, while in Peru the estimated Taylor Rule parameters change visibly from study to study.

Table 4. Taylor Rule: Long-Term Responses

	Brazil	Chile	Colombia	Peru
OLS- IT (2000 – 2012)				
Output Gap	0.89***	0.85*	0.6***	0.05***
Inflation Gap	0.78**	3.02***	2.4**	0.03
OLS- IIT (2000 – 2012)				
Output Gap	0.63***	0.55****	0.6***	0.6***
Inflation Gap	0.36	2.33***	3.2**	0.1
Exchange Rate	0.007	0.04	0.08*	0.035
Credit gap	-0.009	0.03	-0.06	0.035
Mehotra and Sánchez-Fung (2011) (1999 - 2007, GMM) [6]				
Output gap	n.a	1.18***	1.28***	0.27**
Inflation	n.a	1.43***	-0.03	-0.73**
Exchage Rate	n.a	-0.006	0.09**	-0.09**
Moura and Carvalho (2009) (1999 - 2008, OLS) [7]				
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
Mello and Moccero (2011) (1999 – 2006, SVAR)				
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

Note: *p*-values are in the parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

[6] 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.
[7] Authors estimated Taylor Rule by OLS with Newey-West robust standard error. They used the HP filter for each variable definition.

2.2 Markov-Switching Estimation of Taylor Rules

In order to capture possible changes in the policy rule over time, as well as additional variables being considered in the rule (X_t, see next section), we propose an extension of the reaction function (1) which allows sensitivity parameters to change over time: a Markov-Switching methodology based on Hamilton (1994).[8] It has the following form:

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

Now each sensitivity parameter—as well as the residual variance σ—will be allowed to vary across states *S*. The Markov-Switching (MS) approach to the monetary 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 "dovish" on inflation—i.e., reacting more (less) vigorously to the inflation differential and less (more) to the output gap. To the best of our knowledge, our study will be among the first that applies this methodology to emerging IT economies, where the case for a more flexible IT regime is stronger, and where it seems likely that, as the regime matured and macroeconomic conditions evolved, the rule itself changed as well.[9]

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 IT practice were 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

[8] It is assumed that $S_t \in S = \{1, \dots, n\}$, 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-homogenous 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.

[9] In a related forthcoming study, Barajas et al. (2012) explore a simplified version of the above model, focusing on reactions to the exchange rate in a sample of emerging IT countries.

discretion or in response to changes in the broader macroeconomic environment that are not easily captured by the reaction function.

Specifically, the MS approach to the monetary reaction function allows us to ask the following questions: (1) How stable has the policy rule been over time? (2) Has there been a change in credibility of monetary policy? (3) Has there been "fear of floating" in the form of a response to exchange rate movements? (4) Has financial stability concerns been incorporated into the reaction function? (5) Has the response to exchange rate or private credit gap been systematic over the entire period, or episodic, arising only in brief periods? (6) Are there observable changes in behavior surrounding major events, for example the global financial crisis?

Results of the MS 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 procedure. The bottom part of the table shows the frequency of observations in which each regime is most likely,[10] showing that all four countries spend most of the time in Regime 1. *L* is the final value of the log likelihood function maximization; $p=P^{11}$ is the probability of staying in Regime 1 in period *t*, given that the economy is in that state in $t-1$, while σ is the model residual variance. Switching in the residual variance is relevant for all countries and contributes significantly to an improved fit as compared to a simple linear model. We identify low and significant residual variance for all countries in Regime 1, which indicates low volatility throughout these periods and better predictive power. 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. Although the econometric procedure identifies two regimes for each country, in all four cases none of the parameters of the Taylor Rule are significant in Regime 2. Thus, Regime 2 corresponds to a sporadic and short-lived abandonment of the normal reaction function. In Regime 2 the policy rule is not easily understood, given that the determinants of the policy rate are not captured by the conventional variables. Finally,

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

the MS results indicate that the policy rule was remarkably stable in Brazil, as Regime 1 dominates all observations in the period.[11]

Table 5. Markov-Switching Estimation of Taylor Rule (short-term coefficients)[12]

	Brazil		**Chile**		**Colombia**		**Peru**	
	IT	**IT**	**IT**	**IT**	**IT**	**IT**	**IT**	**IT**
Regime	**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 each regime	152	0	142	10	137	15	121	8
L	104.16		51.12		10.34		59.51	

Source: Authors' calculations.
Note: p-values are in the parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

The long-term coefficients of Regime 1 are reported in Table 6. With respect to the OLS coefficients reported in Table 5, two points are worth highlighting: i) 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 the output and the inflation gap; ii) there is an important reduction in the coefficient measuring the response of the repo rate to the inflation gap in the case of Colombia.

[11] 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 (below), where the probability of being in Regime 2 is 0- i.e. Regime 2 never "occurs" at any probability cut-off.
[12] Results are robust to different definitions of the "inflation gap" variable. This estimation is available upon request.

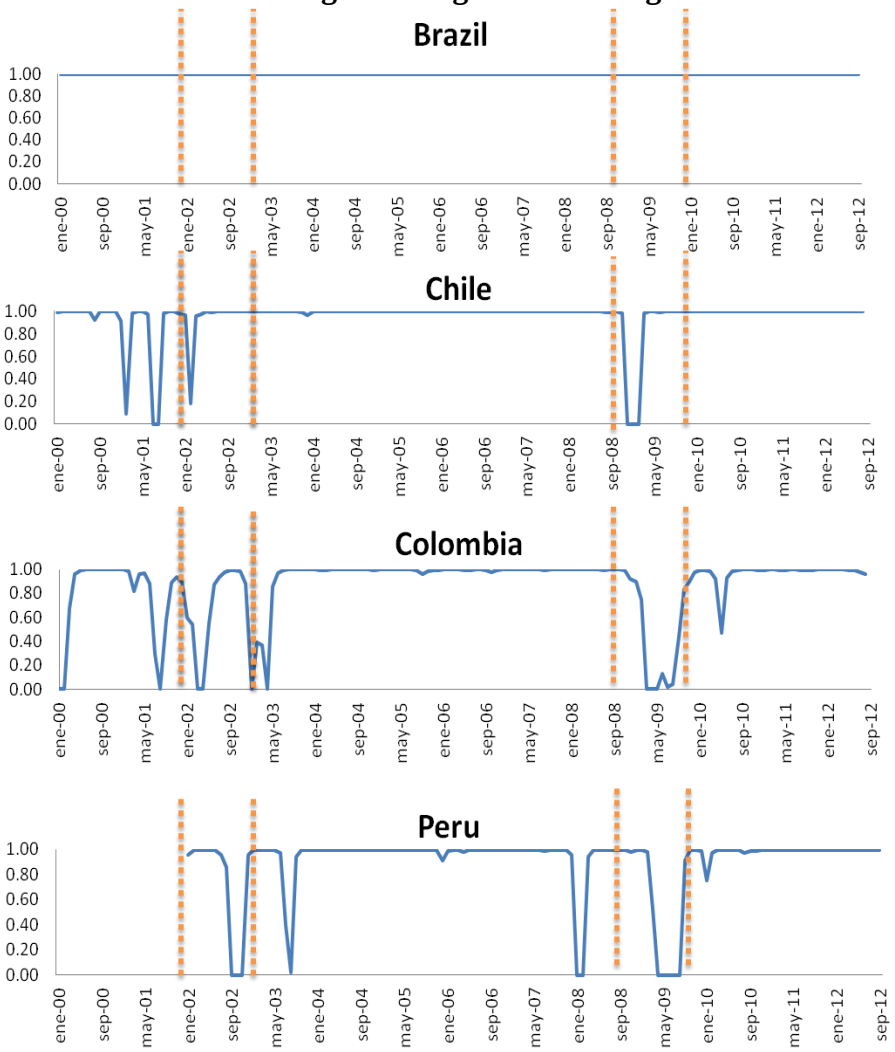
Table 6. Markov-Switching estimation of Taylor Rule (long-term coefficients)

	Brazil	Chile	Colombia	Peru
Regime	**1**	**1**	**1**	**1**
x_t	0. 75***	0.85*	0.39***	0.4*
π^1	0.68**	3.25***	0.95*	1**

Source: Authors' calculations.
Note: p-values are in the parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

In Figure 1 one can observe that the Regime 2 periods greatly coincide across countries. In particular, two episodes stand out, where there was significant turmoil in international financial markets: i) in 2001and 2002, when markets became very hostile towards emerging markets, in part due to the Argentinean crisis of 2001 and also as a consequence of the very negative expectations surrounding the possibility of Lula da Silva's election in 2002; and ii) in late 2008, following the collapse of Lehman Brothers. In both instances the results indicate that the central banks of Chile, Colombia and Peru abandoned the policy rule that we have already described by a well-behaved conventional Taylor Rule.

Figure1. Regime Switching



Source: Authors' calculations. The figure reports probabilities of being in Regime 1 for the specifications in Table 7.

We now turn to a more detailed description of the main episodes of regime change in each country, as reported in Figure 1.

2.2.1 Chile

First episode (May to September 2001). The peso depreciated 20 percent between December 2000 and September 2001. This exceptional event was linked to the significant increase in risk perceptions with regard to Argentina and to a persistent decline in the price of copper. In this context, the BCdC lowered the repo rate from 5.25 percent in February 2001 to 3.5 percent in July 2001 to prevent further deterioration in domestic spending and reductions in inflation below the target range. Moreover, in August 2001 it announced that it would sell up to US$2 billion of international reserves in the spot market for the rest of the year. Finally, the repo rate was gradually increased from 3.5 percent in August 2001 until reaching 6.5 percent in January 2002.

Second episode (January 2009 to May 2009). This episode is related to the collapse of Lehman Brothers and the increase from 189 to 307 bps in the sovereign spread between September and October 2008. At the end of September the BCdC announced the end of a US$8 billion international reserve accumulation program announced in April 2008 and began a program of repos and swaps to provide domestic and foreign liquidity. In October 2008 it extended the range of collateral accepted in its domestic operations, established a liquidity term facility, adjusted its note issuance plan and suspended for the rest of 2009 the issuance of debt instruments with maturity beyond 1 year. When non-conventional policies proved insufficient, it drastically lowered the repo rate, from 7.25 percent in February 2009 to 0.5 percent in August 2009.

2.2.2 Colombia

First episode (mid-2001 to mid-2002). This episode characterized by inflationary pressures coupled with supply-side weakness and adverse TOT shocks. This period corresponds to the end of Pastrana's presidency and the failure of a peace process with leftist guerrillas. By the end of June 2002, inflation was above target due to bad weather conditions, while GDP was 3 percent below potential on account of weak investment and falling exports. Between

June 2001 and July 2002, BdR cut the repo rate seven times, from 11.5 percent to 5.25 percent. In parallel, it injected liquidity with purchases of foreign reserves (US$650 million) and of public debt (US$300 million) in the secondary market. Thus, Regime 2 was associated with additional monetary loosening to provide a boost to a slumping economy, even as inflation was hovering above its target.

Second episode (late-2002 to mid-2003). This period included two major events. First, in what came to be known as the "domestic public debt crisis," during the first week of August 2002 the interest rate on 10-year domestic public debt went up 280 bps. The amount of public debt placed in the domestic capital market touched bottom in September 2002—and would not recover its April 2002 level until May 2003—and in August a public debt auction had to be declared void for lack of demand. Debt prices collapsed and regulatory forbearance was required, in particular to shield institutional investor portfolios that otherwise would have had to be marked-to-market. Second, in the second half of 2002, when polls predicted the victory of Lula da Silva in the Brazilian presidential election, markets became extremely nervous, with spillover effects on Colombia. The EMBI for Colombia reached 1,084 bps in late September, a 70 percent increase from the average of the previous year. In these circumstances, in August 2002 BdR brought forward its pre-announced 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 US$545 million of NIR in order to stem the weakening of the peso.

Third episode (January 2009 to August 2009). Following the collapse of Lehman brothers, Colombia's GDP contracted 0.6 percent in 2009:Q1. A trade embargo by Venezuela and Ecuador contributed to a sharp export contraction between January and May. The BdR responded by removing all controls on capital inflows in September 2008 and reducing reserve requirements in October, after having increased them in 2007. Three months later the BdR decided to aggressively decrease the repo rate, which went from 10 percent in December 2008 to 4% in October 2009. Finally, the central bank decided that most of the additional liquidity to be provided towards the end of 2009 would be instrumented through NIR purchases (NIR increased almost US$2 billion between May and September 2009) and purchases of public debt.

2.2.3 Peru

First episode (September 2002 to December 2002). This event was also linked to uncertainty surrounding the outcome of the Brazilian election. The BCdlRP raised the interbank rate from 2.9 percent in July to 5.4 percent in September as a preventive action. In addition, in response to this critical situation, it sold US$127 million in the open market in September 2003.

Second episode (May 2009 to August 2009). According to the June 2009 inflation report, the economy expanded only 1.8 percent in the first quarter of 2009 with a 3 percent decline in exports and a 0.8 percent decline in domestic demand. In March 2009 the EMBI was almost 200 points above the March 2008 level. Under these circumstances, the BCdlRP decided to use both conventional and non-conventional instruments. Firstly, in September 2008 it lowered reserve requirements on short-term bank deposits held by foreign residents from 120 percent to 35 percent. Secondly, it sold US$6.8 billion NIR between September 2008 and March 2009. Thirdly, between September 2008 and February 2009 it lowered to 6 percent the marginal reserve requirements on domestic currency bank deposits and totally eliminated those requirements in June 2009. When these policies were no longer sufficient, the central bank lowered the repo rate almost 500 basis points between February and August 2009.

2.2.4 Discussion

Across all three countries, several of the episodes just described correspond to central bank policy going beyond what the usual (Regime 1) reaction function would have called for, maintaining a looser stance and complementing low interest rates with other tools (i.e., liquidity injections and exchange market intervention). In Chile's first episode, the copper price may have been giving 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 surpassing the target. The Lehman bankruptcy and uncertainties surrounding the impending Lula presidency seem to have led central banks to consider potential spillovers which had not yet materialized in the output gap, thus spurring them to respond more aggressively than usual.

Table 7 illustrates the relative looseness of the Regime 2 episodes following the Lehman bankruptcy, where the actual policy rate was kept below the predicted (Regime 1) level in all three countries, particularly in Chile and Peru.[13]

Table 7. Actual vs. Estimated Repo Rate during the Lehman Crisis

	Period	Actual average	Regime 1 policy rule
Chile	January to May (2009)	4.85	6.21
Colombia	January to June (2009)	7.80	7.99
Peru	May to August (2009)	2.77	3.69

Source: Authors' calculations. The period for the average was chosen according to the Regime Switching results.

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2.3. 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 clearly led to the promotion of macro-prudential 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 macro-prudential policies that seek to smooth out credit cycles (Dell'Ariccia et al., 2012). Along these lines, many countries in recent years 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.

[13] Two episodes stand out as being different, however. Colombia's second episode contained an element of fiscal dominance, in which the monetary objective was temporarily superseded by fiscal concerns. Finally, Peru's central bank appeared to respond differently to the Lula da Silva episode, abandoning its usual rule in order to tighten and therefore stem capital outflows.

Agénor and Pereira da Silva (2013) have recently promoted the idea that central banks should follow an Integrated Inflation Targeting framework (IIT) that, among other features, allows for the possibility that, in setting its repo rate, central banks should consider not only the output and inflation gaps, but also variables that might pre-empt problems with regard to financial stability (i.e., excessively rapid credit expansion). One such variable is the rate of growth of credit, whose inclusion in the reaction function can be derived from an optimization problem—that is, 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.[14] 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 (Taylor, 2001) on account of its possible effect on inflation and output. The exchange rate was also incorporated in the IT policy rule for open economies proposed by Svensson (2000). However, the IIT framework that we discuss here, following Agenor and Pereira da Silva (2012), includes an exchange rate variable not only on account of its impact on aggregate demand but also on account of its implications on 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 a currency appreciation as in Levy-Yeyati and Sturzenegger (2001).[15]

Needless to say, there are serious challenges in implementing IIT, including prominently the fact that credibility is a central element of any IT framework, and credibility could be compromised with a proliferation of goals to be 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 observe the kinds of financial sector disruptions that characterized several more mature economies—have, in fact, been operating as if under an IIT framework in the recent past.

[14] Recent theoretical work has shown how central banks might operationalize the use of financial stability indicators in their reaction function (Woodford, 2012). See, also Agénor and Pereira da Silva (2012) and Disyatat (2010).

[15] 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, Restrep and García, 2009).

While it is evident that many macro-prudential policies had been put in place well ahead of the 2008 financial crisis in the four countries under study, an additional issue worth exploring has to do with the possibility that, in practice, expanded Taylor Rules have also been in place.

We therefore turn to estimating equation (2) above in a specification in which a vector of additional variables *Xt* is incorporated to reflect the central bank's possible response to the exchange rate and to credit growth. With regard to the exchange rate, we will test for the possibility that, the interest 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 repo rate to real credit growth C as a proxy for signals regarding financial stability. OLS estimations using monthly data for 2000-2012 are reported in Tables 8 and 9. 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 the output and inflation gaps have played a role in the determination of the repo rate. In particular, in none of the countries is there a significant response either to the deviation from trend in real exchange rate or to deviation from trend in the real credit gap.

Table 8. Integrated Inflation Targeting (Short-term OLS estimations)

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

Source: Authors' calculations.
Note: p-values are in the parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 9. Integrated Inflation Targeting (Long-Term OLS estimations)

	Brazil	Chile	Colombia	Peru
Regime	**1**	**1**	**1**	**1**
x_t	0.63***	0.55****	0.6***	0.6***
π^1	0.36	2.33***	3.2**	0.1
$RER_d hp$	0.007	0.04	0.08	0.035
$C1$	-0.009	0.03	-0.06	0.035

Source: Authors' calculations.
Note: p-values are in the parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Interestingly, we obtain similar results using the Markov-Switching procedure for the same specification, as reported in Table 10 (short-term coefficients) and Table 11 (long-term coefficients). Once more, the bottom part of the table shows the frequency of observations in which each regime prevails;[16] 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 repo 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 economic terms. As an example, while in the short run for Colombia

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

an increase of one percent in the output gap represents a 0.04 percent increase in the repo 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, in which the policy rate is highly sensitive to either real exchange rate movements or credit growth.[17] Finally, once again in all four cases none of the parameters are significant in Regime 2. Importantly, this result also holds in estimations in which additional explanatory variables such as each country's EMBI and the VIX volatility index were introduced into the estimation.[18] Thus, Regime 2 again corresponds to a sporadic and short-lived abandonment of the normal reaction function.

[17] These results are robust to different definitions of the "credit" variable (see Barajas, *et al*, 2014).
[18] We report these results in Barajas, et al (2014). Results are consistent with those using only credit and real exchange rate deviations from trend.

Table 10. Integrated Inflation Targeting (Short-term MS estimations)

	Brazil		Chile		Colombia		Peru	
	IIT	**ITT**	**IIT**	**ITT**	**IIT**	**ITT**	**IIT**	**ITT**
Regime	**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)
$RER_d hp$	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)
σ^{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.
Note: p-values are in the parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
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 11. Integrated Inflation Targeting (Long-Term MS Estimations)

	Brazil	Chile	Colombia	Peru
Regime	**1**	**1**	**1**	**1**
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.
Note: p-values are in the parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

3. Exploring the 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 one time or another, intervened directly in the FX market to defend or target a certain level of the exchange rate or to moderate extreme fluctuations. After all, the region has had a justifiable history of concern 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 IT, one might expect some degree of exchange rate targeting, especially in the face of large external shocks.[19]

Interestingly, central banks consistently argue that if and when they intervene in the FX market, they do so either as a prudential measure to replenish international reserves or on account of concerns for exchange rate volatility. For all four countries we have thoroughly reviewed the minutes of the monetary policy committee and the inflation report 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

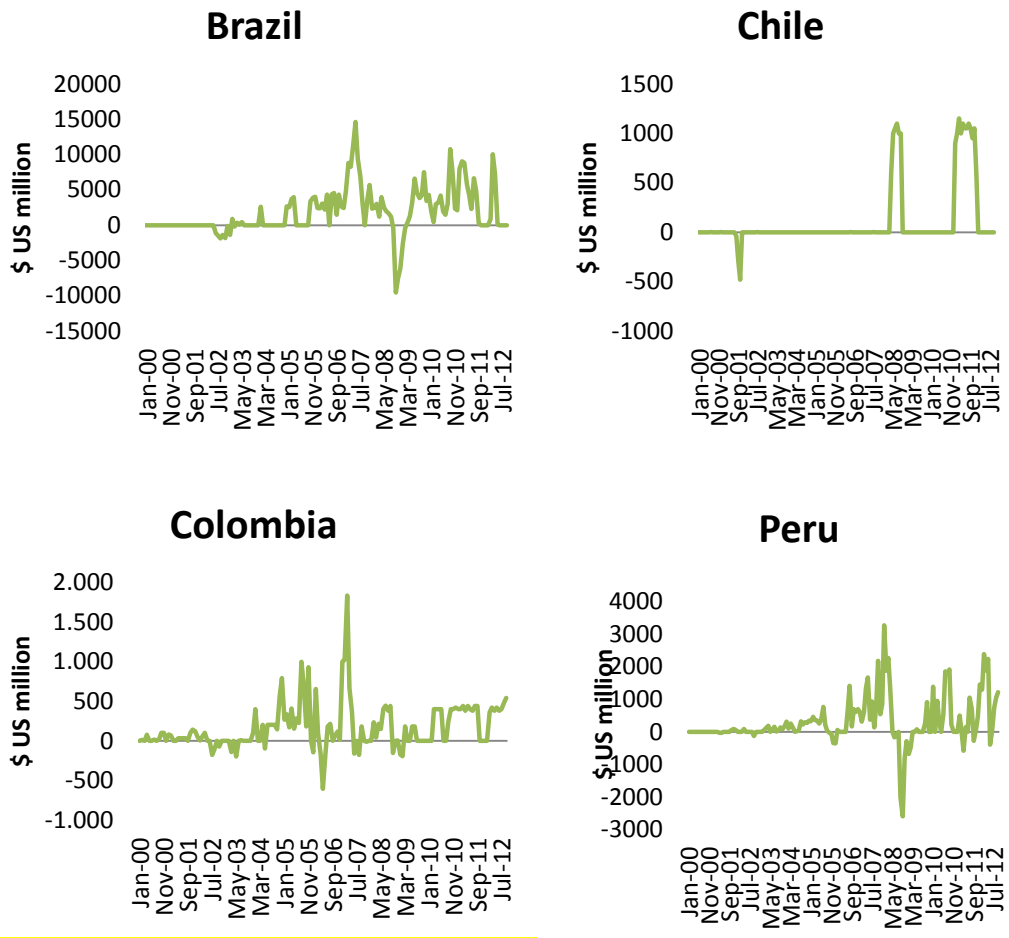
[19] Capital markets appear to recognize the advantages of intervention; one empirical study shows that, regardless of the stated or de jure regime, emerging economies displaying greater intervention are rewarded in the form of lower sovereign spreads (Barajas, Erickson and Steiner, 2008).

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 FX market. The Peruvian authorities claim to intervene on the basis of two objectives: to improve the level of NIR and to control exchange rate volatility. Based on its inflation reports, the BCdlRP intervened in the FX markets to alleviate real exchange rate volatility during the market uncertainty in 2002 and just after the Lehman Crisis. In the case of Chile, in addition to these two objectives, reference is made to stabilization of financial markets, especially during the Lehman Crisis when the Central Bank decided to introduce a set of non-conventional measures. Interestingly, the central bank of Brazil provides no explanation for its intervention in the FX market. This is in line with Chang (2007, page 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 main determinants. In Figure 2 we report monthly data on net central bank purchases of foreign exchange (i.e., purchases minus sales), the FCL variable in what follows. From the figure it is quite evident that intervention was not very large nor common at the beginning of IT—behavior that is consistent with the view expressed in Barajas, Erickson and Steiner (2008) in the sense that in the initial years of the IT 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.[20] A salient feature of Figure 3 refers to the fact 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.

[20] A caveat is in order. In this paper we only analyze FX intervention by central banks, although intervention may at times take place through sovereign wealth funds and/or SOEs.

Figure 2. Net Foreign Exchange Purchases by the Central Bank



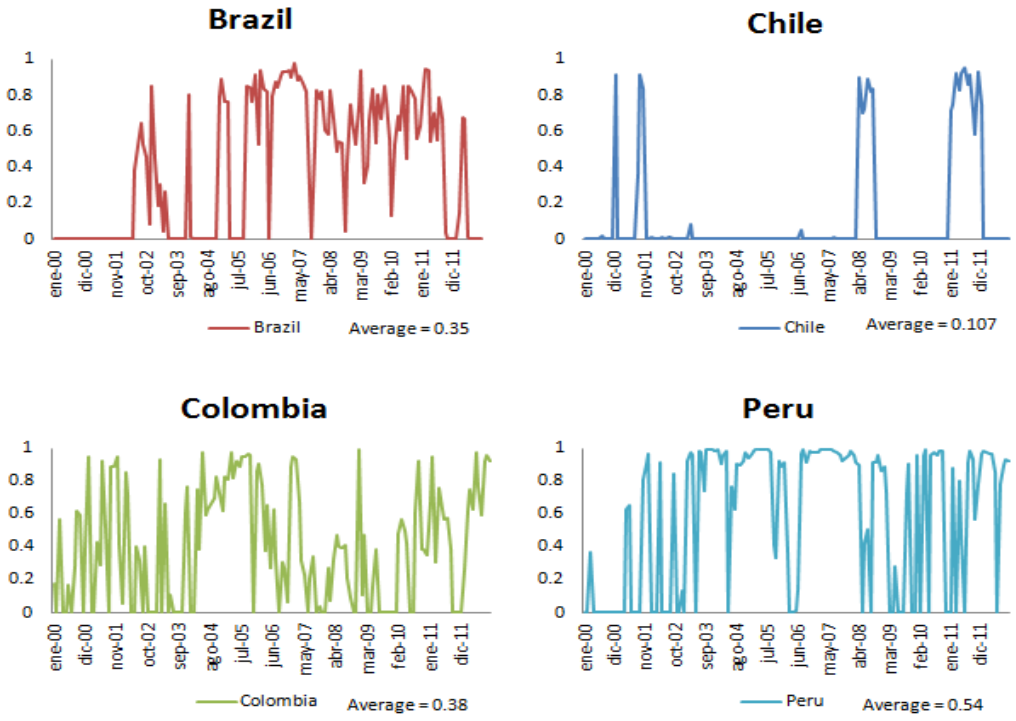
Source: The series for Peru, Colombia and Chile were originally taken from Central Bank data. In Brazil data was kindly provided by BTG Pactual.

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 of the relative magnitude of FX intervention:

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

where FCI are central bank purchases and sales in the FX market[21] (Figure 3, in U.S. dollars), BM is base money and e is the nominal U.S. dollar exchange rate. The numerator measures monthly FCI expressed in domestic currency 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, as all of the action in the exchange market would occur on changes in quantities rather than in the exchange rate. Also note that *INTERV* is always positive, making no distinction between purchases or sales of the same magnitude.

Figure 3. Intervention Index



Source: Authors' calculations.

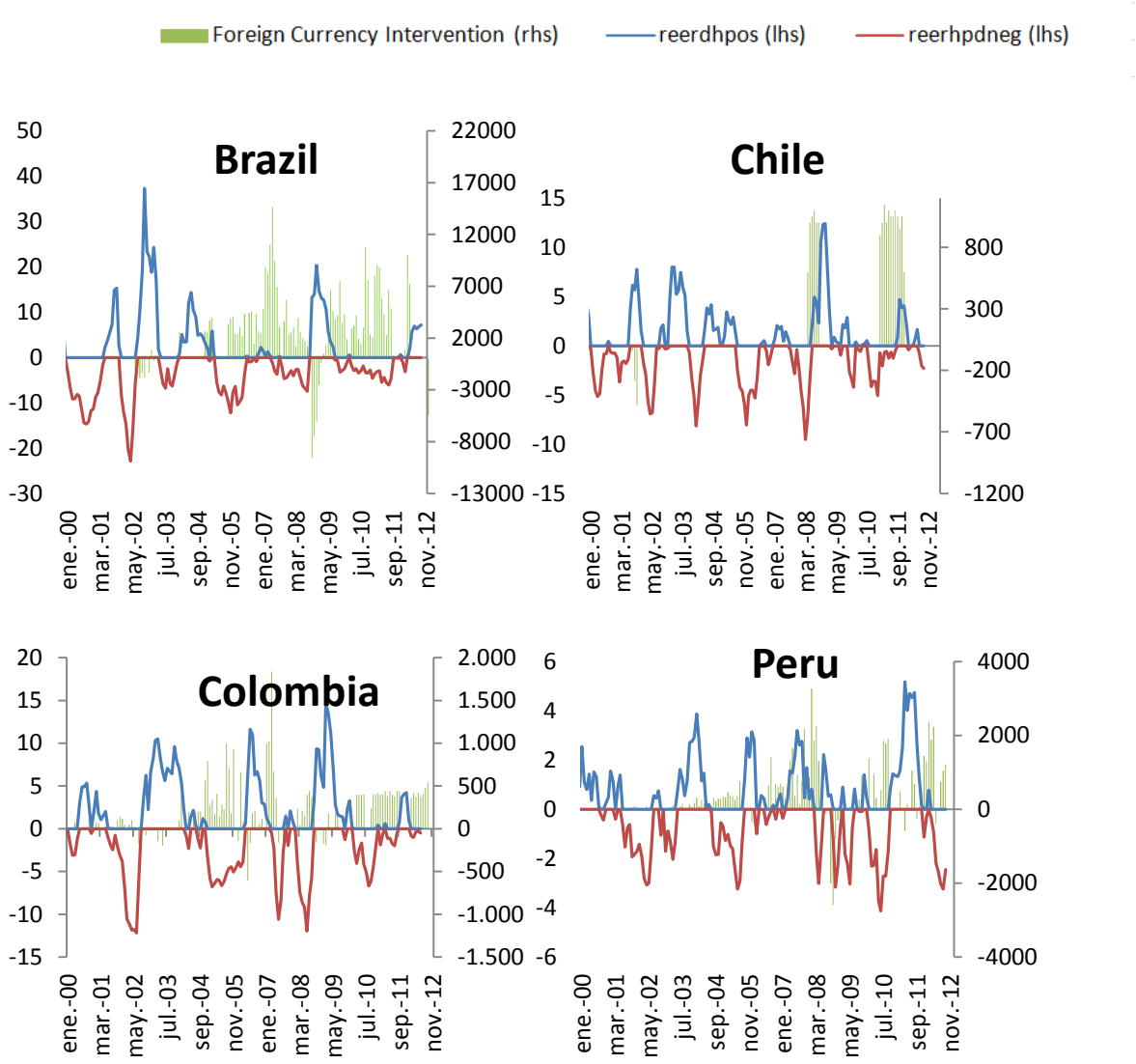
[21] Prior estimations of INTERV have generally used changes in NIR instead of purchases and sales in the F/X market. That approach is problematic for many reasons, including the fact that, because of valuation issues, international reserves can change (in US dollar terms) in spite of the fact that no F/X 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 shows *INTERV* for Brazil, Chile, Colombia and Peru, from January 2000 to September 2012. Four aspects are worth highlighting: i) all four countries intervene, and quite substantially at times; ii) 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; iii) with the exception of Chile, the other countries intervene quite often; and iv) in all four countries there are instances in which the exchange rate regime behaves as if it were a fixed exchange rate.

Figures 4 reports three series for each country: i) FCL, net foreign currency purchases; ii) RER*hpp* are the positive deviations of the RER from its HP trend, indicating that the RER is *weaker* (more depreciated) than its long-run trend level; and iii) *RERhpn*, the negative deviations when the RER is *stronger* (more appreciated) than its trend level. Deviations in the 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 (US$ million). Figures 4 support the following stylized facts: i) 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; ii) there is no general coincidence among countries in the periods of large interventions. While Brazil and Peru undertook their largest sales in the F/X 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: (1) Does intervention respond to perceived real exchange rate misalignments; if so, is the response symmetric, treating depreciations and appreciations similarly? (2) Does intervention respond to increases in exchange rate volatility? (3) Is intervention a complement to interest rate policy, in that it also responds to changes in the inflation gap? (4) Is there evidence that forex intervention serves to establish a certain level of international reserves?

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



Source: Author´s calculations. The series fwere originally taken from Central Bank data. In Brazil data provided by BTG Pactual.

Notes: The left axis is for deviations in the Real Exchange rate from the HP ($reer_d hp$). The right axis is for Foreing Curreny Purchases and is measured by $ US millions .

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 provide evidence as to whether FX interventions are motivated by issues of *exchange rate volatility* or *accumulation of reserves* (as is usually argued by central

bankers) or if concerns with regard to *exchange rate levels* and/or inflation are relevant. In particular, we estimate the following "reaction function" for interventions in the foreign currency market:

$$FCI_t = \theta + \gamma_1(RER_d hp) + \gamma_2(D_1 * RER_d hp)_t + \gamma_3(RER_d hp * RER\sigma^2) + \gamma_4(RER_d hp * NIR) + \gamma_5(E_t\pi_{t+1} - \pi_t^T) + \varepsilon_t \quad (3)$$

The dependent variable, FCI, is monthly net foreign currency purchases. We consider several explanatory variables. 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 asymmetric response, depending on whether the currency is relatively strong or weak. For this purpose, we interact *RERhp* with a dummy variable D_1 (equal to 1 when $RER_d hp$ is below trend—i.e., i.e. relatively strong—and equal to 0 when it is above trend—i.e., relatively weak. Third, we want to assess the possible importance of exchange rate volatility as a determinant of central bank intervention in the F/X market. With that purpose in mind, we include the interaction between $RER_d hp$ and $RER\sigma^2$ to test if central banks intervened more forcefully when volatility has been higher. Fourth, we include the interaction between NIR (the level of net international reserves) and $RER_d hp$ to uncover the relationship between foreign currency net purchases and the level of Net International Reserves. Finally, we include the inflation gap (as in the monetary reaction function) to determine whether FX intervention is directly related to an inflation objective. For example, in the face of rising inflation, the central bank might intervene to prevent a depreciation that would feed into inflation via pass-through.

Of course, there is a potential endogeneity problem to the extent that the level of the exchange rate as well as the inflation gap could potentially depend on FX intervention itself. We therefore undertake 2SLS estimations using as instruments the FED interest rate, EMBI and the VIX index of volatility in the U.S. stock market as reflecting external conditions that have an impact on the exchange rate and domestic inflation.[22] The validity of the instruments is supported by the results reported in Table 12.

[22] For the NIR and $RER\sigma^2$ we used their lags as instruments

Table 12. First Stage (2SLS)[23]

Column	(1.1)	(1.2)	(1.3)	(1.4)
	Real Exchange Rate Misalignment			
Country	Brazil	Chile	Colombia	Peru
VIX		0.18** (0.01)	0.22** (0.01)	
EMBI	0.008*** (0.00)			
i FED				0.16*** (0.00)
R^2	0.32	0.22	0.28	0.33
Observations	153	153	153	153

Source: Authors' calculations.
Note: p-values are in the parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

The second-stage results, reported in Table 13, can be summarized as follows: i) in Brazil, Chile and Peru deviations from trend in the RER are significant determinants of interventions in the FX market; ii) the coefficients for $D_1 * RER_d hp$ support the idea that in Chile, Colombia and Peru intervention is asymmetric, with greater intervention (purchases) when the currency is strong than (sales) when it is weak; iii) in Brazil, while there is symmetric intervention, intervention is negatively related to volatility; iv) only in the case of Chile are interventions related to the inflation gap, but the sign of the relationship is not the expected one; and v) only in Chile does intervention intensify in periods of higher volatility. Contrary to statements from all central banks, Table 6 suggests that intervention in the FX market in the other three countries does not seem to be related to RER volatility. Finally, the interaction of *RERdhp* does not lend much support to the idea that intervention is done to build up a stock of reserves. If there were an implicit target level for reserves,

[23] 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.

then we would expect intervention to decline as the level of reserves increases. However, this is only marginally so in Brazil, and not the case in the other three countries.

Table 13. Determinants of Intervention in the F/X Market (2SLS)

	Description	**(1.1)**	**(1.2)**	**(1.3)**	**(1.4)**
		Brazil	Chile	Colombia	Peru
Intercept		808.5* (0.05)	1297 *** (0.00)	140.5*** (0.00)	39152** (0.01)
$RERdhp$	RER deviations from trend	-457*** (0.00)	-241.2*** (0.00)	-67.9 (0.15)	-48158** (0.02)
$D1 * RERdhp$	Negative RER deviations from trend (currency too strong)	-79.5 (0.19)	-824.4*** (0.00)	-61.9** (0.04)	-51513** (0.02)
$RERdhp * RER\sigma^2$	RER deviations from trend interacted with volatility	1.43** (0.02)	-6.56** (0.00)	0.40 (0.62)	-0.22 (0.16)
$RERdhp * NIRlevel$	RER deviations from trend interacted with NIR level	-0.001* (0.09)	0.003 (0.20)	0.001 (0.49)	-0.01 (0.35)
Inflation gap	Inflation Gap	243.9 (0.37)	248*** (0.00)	3944 (0.49)	-104.1 (0.41)

Source: Authors' calculations.
Note: p-values are in the parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

4. Summary and Conclusions

As more and more central banks in emerging economies have adopted IT, 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 IT adoption presupposes the 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 global financial crisis was partially determined by the complacency that came about after years of low and stable inflation. With CPI 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 including real estate and the stock market. Policy prescriptions following the financial crisis include the use of macro-prudential measurers and possibly even the incorporation of a "private credit gap" measure in monetary reaction function of central banks.

In short, there are strong arguments in favor of implementing a flexible version of IT, 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" IT approach, as proposed by Agenor 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 IT regime. Some studies surveyed in this paper have then sought to assess how much flexibility has actually been present in IT 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 a panel of IT (and sometimes non-IT) 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 IT countries and has been effective in reducing exchange rate volatility.

In this paper we focus on the practice of monetary policy in four early IT adopters in Latin America: Brazil, Chile, Colombia and Peru. Our sample period, 2000-2012, encompasses virtually their entire experience with IT. By focusing on individual country cases rather than a panel data approach, and by adopting a flexible econometric methodology, we are able to capture cross-country heterogeneity as well as structural shifts that may have occurred in each country.

Our first analytical exercise focuses on the central bank policy reaction function, using a Markov-Switching methodology that allows the data to "speak for itself" 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 2002-3 period of heightened risk aversion toward emerging markets and the 2008-9 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 the rule. We also find evidence that the policy rate in Colombia responded to a real exchange rate gap—measured by the deviation in the real effective exchange rate from its trend—and in Peru it responded to a private credit gap—measured as the excess growth of credit over that of output. The MS 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 IT experiences matured. On the other hand, this result is encouraging; 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 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 the currency is perceived to be weak. That is, the fear of appreciation is greater than that of depreciation. Moreover, forex intervention in general does not seem to be related neither to exchange rate volatility nor to the level of international reserves, nor is it simply another instrument aimed at stabilizing inflation.

In all, we provide evidence that central banks appear to have pursued two distinct objectives with two different instruments: an inflation objective using a mostly standard Taylor rule—except in the case of Colombia, where the exchange rate gap plays a role—and an exchange rate objective through interventions in the FX market. At least to date, there does not seem to have been an inconsistency in the pursuance of these two objectives, in terms of a visible loss of credibility. Thus, although forex interventions reflect "fear of floating," as emphasized by Reinhart (2013), this has not, at least to date, 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. Finally, financial stability concerns have been addressed in the three of the countries solely with the use of macroprudential measures, with Peru incorporating a private credit gap measure directly into the reaction function as well.

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Appendix A. Variables Description for Brazil

- Short-term rate (SELIC- last day of the month): From Banco Central do Brasil.
- x_t (Output Gap): It is the percentage deviation of real output from trend. Real output, *Y*, is the monthly GDP (accumulated in the last 12 months) at constant 2008 prices obtained from the Banco Central do Brasil and seasonally adjusted by us.[24] The trend, Y^*, comes from a conventional HP estimation.
- $E_t\pi_{t+1}$: Expectations are taken from a monthly survey developed and published by Latin Focus Consesus Forecast.[25]
- π_t^T: The inflation target is announced by the Banco Central do Brasil and can be found in the "Histórico de Metas para a Inflação no Brazil"
- π_t *:* Inflation corresponds to the annual variation from the CPI. Original series were taken from the Central Bank.
- $RER_d hp$ ($RER - RER\ hp\ /\ RER\ hp$)*:* Our estimations of the of percentage deviations real exchange rate (HP) trend. RER taken from Banco Central do Brasil. It uses CPI as deflator and comprises the 10 main trading partners.
- $RER\ \sigma^2$: 6-month rolling variance of the real exchange rate; our own calculations.
- $C\ 1$ ($\Delta\ RC - \Delta\ x_t$): Credit Growth with respect to the same month of the previous year, deflated by changes in the CPI and defined as the gross loan series. Source: Banco Central do Brasil. Output gap x_t growth with respect to the same month of the previous year.
- $C\ 2$ (RC/GDP): Credit defined as the gross loan series. Source: Banco Central do Brasil. The real output is the Output gap x_t.
- $C\ 3$ (*Non-Performing Loans/ RC):* Non-Performing Loans over the gross loan series taken from the Banco Central do Brasil.
- FCI_t ($Foreign\ Currency\ Intervention$): Series "Intervenções do Banco Central." This information includes regular spot intervention and all other varieties except derivatives. It includes forward sales/purchases; means repos; lending of foreign currency by the CB to domestic (financial) counterparties; and lending of foreign currency by the CB earmarked for lending as export financing. These data were provided by BTG Pactual.
- $EMBI\ and\ NIR$: This information is available in the Banco Central do Brasil. EMBI was 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.

Appendix B. Variables Description for Chile

- i_t (Short-term REPO rate): first of the month, from the Banco Central.
- $i_{j,t-1}$: Lag for one period of the j-th short-term REPO rate.
- x_t (Output Gap): Measured as percentage deviations of real output from trend. Real output, *Y*, is the monthly IMACEC (*indicador mensual de actividad económica*) in 1990 constant prices, taken from Banco Central de Chile and seasonally adjusted by us. After we obtain the monthly GDP series, the trend, Y^*, comes from a conventional HP estimation.
- $E_t\pi_{t+1}$: Inflation expectations come from a monthly survey developed and published by Latin Focus Consesus Forecast.[26]
- π_t^T: The inflation target is announced by the Banco Central of Chile and can be found in its Inflation Reports.
- π_t *:* Inflation corresponds to the annual variation from the CPI. Original series were taken from the Central Bank.
- RER_dhp ($RER - RER\ hp\ /\ RER\ hp$) : Our own calculations of percentage deviations of the real exchange rate from its (HP) trend. The real exchange rate is taken from the Central Bank data (21 main trading partners, deflated by the CPI).
- $RER\ \sigma^2$: 6-month rolling variance of the real exchange rate; our own calculations.
- $C\ 1$ ($\Delta\ RC - \Delta\ x_t$): Credit Growth with respect to the same month of the previous year, deflated by changes in the CPI and defined by the gross loan series. Source: Superintendencia de Bancos e Instituciones Financieras. Output gap x_t growth with respect to the same month of the previous year.
- $C\ 2\ (RC/GDP)$: Credit defined by the gross loan series. Source: Superintendencia de Bancos e Instituciones Financieras. The real output is the GDP monthly calculation based on the methodology proposed by Litterman (1983).[27]
- $C\ 3$ (*Non Performing Loans/ RC):* Non-Performing Loans over the gross loan series taken from the Superintendencia de Bancos e Instituciones Financieras.
- FCI_t ($Foreign\ Currency\ Intervention$): Series "Activos de reservas internacionales" component "Operaciones de cambio con banco." Source: Banco Central de Chile.
- VIX: Obtained from Bancolombia; original series comes from Bloomberg.
- $Terms\ of\ Trade$: Quarterly IMF data converted to monthly based on Litterman (1983).

[26] 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.

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

Appendix C. Variables Description for Colombia

- i_t (Short-term REPO rate): first of the month, from Banco de la República,
- $i_{j,t-1}$: Lag for one period of the j-th short-term REPO rate.
- x_t (Output Gap): measured as the percentage deviation of real output from trend. Real output, Y, is the monthly IPIR (Indice de Producción Industrial) taken from Banco de la República at 1990 constant prices and seasonally adjusted by us. After we obtain the monthly GDP series, the trend, Y^*, comes from a conventional HP estimation.[28]
- $E_t\pi_{t+1}$: Inflation expectations come from a monthly survey developed and published by Latin Focus Consesus Forecast.[29]
- π_t^T: The inflation target is announced by the BdR and can be found in its reports to the Congress.
- π_t *:* Inflation corresponds to the annual variation from the CPI. Original series were taken from the Central Bank.
- $RER_d hp$ ($RER - RER\ hp\ /\ RER\ hp$): Percentage deviations in the real exchange rate from its (HP) trend, based on our own calculations. The real exchange rate is taken from BdR. This index uses CPI as a deflator and is in reference to the weighted average of the 20 main trading partners.
- $RER\ \sigma^2$: 6-month rolling variance of the real exchange rate; our own calculations.
- $C\ 1$ ($\Delta\ RC - \Delta\ x_t$): Credit Growth with respect to the same month of the previous year, deflated by changes in the CPI and defined as the gross loan. Source: Superintendencia Financiera de Colombia. Output gap x_t growth with respect to the same month of the previous year.
- $C\ 2$ (RC/GDP): Credit defined as the gross loans. Source: Superintendencia Financiera de Colombia. The real output is the GDP monthly calculation based on the methodology proposed by Litterman (1983).[30]
- $C\ 3$ (*Non-Performing Loans/ RC):* Non-Performing Loans over the gross loan series. Source: Superintendencia Financiera de Colombia
- FCI_t ($Foreign\ Currency\ Intervention$): Series "Operaciones de Compra - Venta de Divisas del Banco de la República" (without Government sales). Source: BdR.
- $Terms\ of\ Trade\ and\ NIR$: Source: Banco de la República.

[28] 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.

[29] 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 cutting 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.

[30] 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.

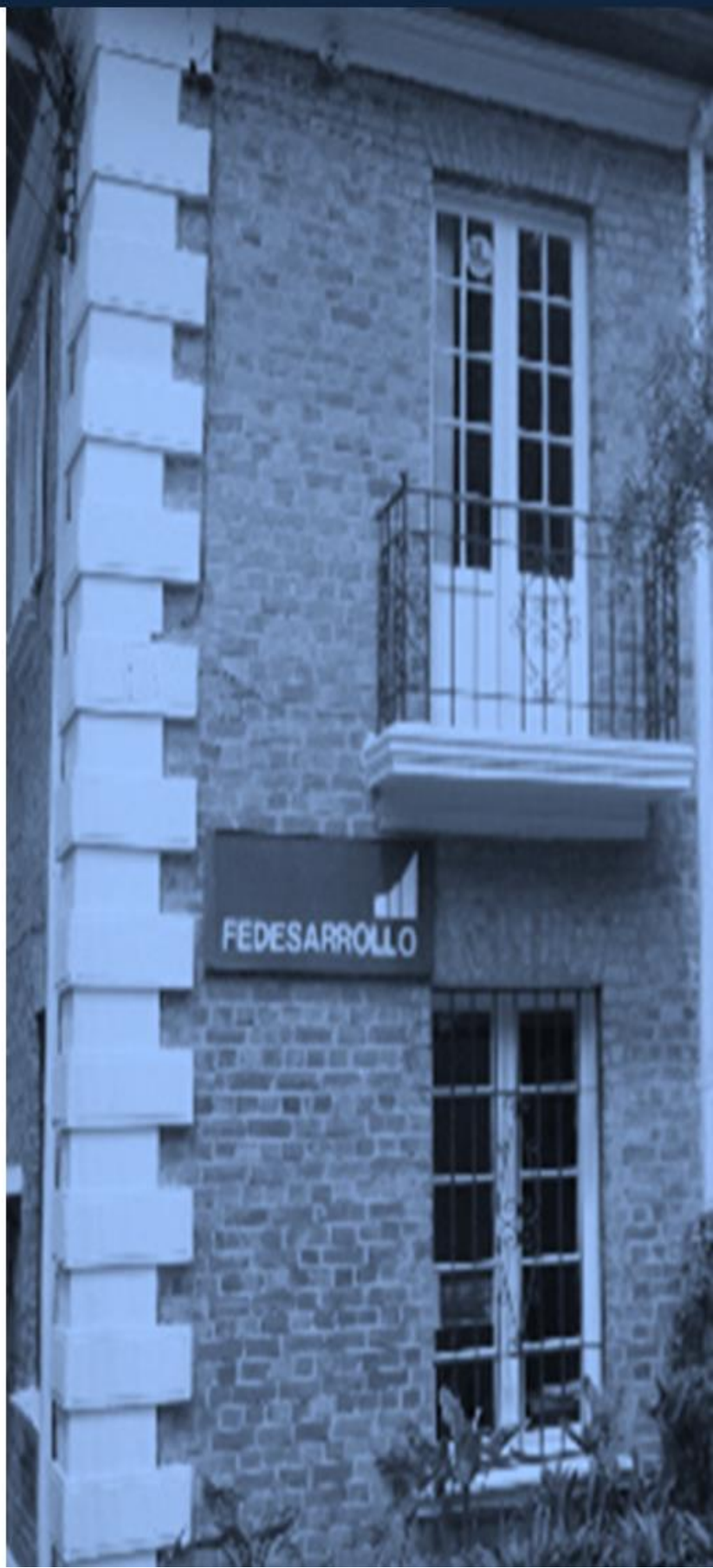
Appendix D. Variables Description for Peru

- i_t (Interbank Rate): Series taken 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): It is measured as the deviations of real output from trend. Real output, *Y*, is the monthly GDP at constant 2008 prices from the Banco Central de la Reserva. It was seasonally adjusted by us. The trend, Y^*, comes from a conventional HP estimation.
- $E_t\pi_{t+1}$: Inflation expectations come from a monthly survey developed and published by Latin Focus Consesus Forecast.[31]
- π_t^T: The inflation target announced by the Banco Central de la Reserva del Perú and can be found in its inflation reports.
- π_t *:* Inflation corresponds to the annual variation from the CPI. Original series were taken from the Central Bank.
- $RER_d hp$ ($RER - RER\ hp\ /\ RER\ hp$): Our own estimations of the percentage deviations in the real exchange rate from its (HP) trend. The real exchange rate is taken from Banco Central de la Reserva de Perú. It uses CPI as the deflator and is a weighted average of the 20 main trading partners.
- $RER\ \sigma^2$: 6-month rolling variance of the real exchange rate; our own calculations.
- $C\ 1$ ($\Delta\ dRC - \Delta\ x_t$): Credit Growth with respect to the same month of the previous year, deflated by changes in the CPI and defined as the gross loan. Source: Banco Central de la Reserva del Perú. Output gap x_t growth with respect to the same month of the previous year.
- $C\ 2$ (dRC/GDP): Credit defined as the gross loans. Source: Banco Central de la Reserva del Perú. The real output is the Output gap x_t.
- $C\ 3$ (*Non-Performing Loans/* dRC*):* Non-Performing Loans over the gross loan series. Source: Banco Central de la Reserva del Perú.
- FCI_t ($Foreing\ Currency\ Intervention$): Series "Compras (ventas) netas mensuales de dólares en el mercado por parte del Banco Central de Reserva del Perú."
- $FED\ Interest\ Rate$: Source: Federal Reserve System
- NIR: Source: Banco Central de Reserva del Perú

[31] 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.

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