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Inflation Targeting in Latin America: the role of the exchange rate Regime de Metas de Inflação na América Latina: o papel da taxa de câmbio

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Master Dissertation presented to the Department of Economics of the School of Economics, Administration, and Accounting of the University of São Paulo (FEA-USP) for obtaining the degree of Master of Science.

Concentration Area: Economic Theory.

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RESUMO

FREDDO, L. A. M. **Regime de Meta de Inflação na América Latina: o papel da taxa de câmbio**. Dissertação (Mestrado) – Faculdade de Economia, Administração e Contabilidade, Universidade de São Paulo, São Paulo, 2019.

Diversas economias emergentes adotaram metas de inflação como arcabouço de política monetária nas últimas décadas — geralmente após um período de algum tipo de política de câmbio fixo. Sob um regime de metas de inflação, em teoria, a taxa de câmbio deveria flutuar livremente. As autoridades monetárias, na verdade, deveriam se preocupar com a propagação de efeitos secundários de movimentos da taxa de câmbio sobre os preços — através da demanda e/ou das expectativas, mas sem tentar influenciar a própria trajetória da taxa de câmbio. A realidade de economias emergentes, no entanto, revela que a taxa de câmbio é de crucial importância não apenas para a condução da política monetária mas também devido a seus efeitos sobre a economia doméstica, por causa de suas susceptibilidades e vulnerabilidades aos fluxos de capital pró-cíclicos. Neste sentido, o objetivo desta dissertação é o de investigar como movimentos da taxa de câmbio influenciam intervenções no mercado das autoridades monetárias latino-americanas (Brasil, Chile e Colômbia) através de dois instrumentos, isto é, do mercado de câmbio e da taxa de juros de curto-prazo, estimando, neste último caso, funções de reação monetária. A principal contribuição é a incorporação de potenciais assimetrias — maior preocupação com apreciação ou depreciação cambial — no comportamento das autoridades monetárias. Os resultados esclarecem o fato de que, apesar de a taxa de câmbio desempenhar um papel crucial para os regimes de metas de inflação na América Latina, a utilização dos instrumentos variaram em termos de intensidade, propósito e assimetria em relação a movimentos da taxa de câmbio. No Brasil, as autoridades monetárias comportaram-se assimetricamente com relação a depreciações cambiais, com ambos instrumentos. No Chile, a assimetria verificada foi com relação a apreciações cambiais, também com ambos instrumentos, mas as intervenções no mercado cambial foram bem mais modestas. Na Colômbia, as autoridades monetárias comportaram-se assimetricamente com relação a apreciações cambiais no mercado de câmbio, sem evidência de assimetria através da taxa de juros. A potencial razão por trás das assimetrias também é diferente: enquanto no Brasil as autoridades monetárias preocuparam-se mais com depreciações cambiais, potencialmente por causa de questões relacionadas aos seus objetivos de inflação, no Chile e na Colômbia, elas preocuparam-se mais com apreciações cambiais, potencialmente por causa de questões relacionadas ao balanço de pagamentos. Ademais, a intensidade e a frequência das intervenções, especialmente no mercado de câmbio, levantam a questão, para os casos do Brasil e da Colômbia, se as autoridades monetárias tentaram influenciar de alguma maneira a própria trajetória da taxa de câmbio.

Palavras-chave: Metas de inflação; Taxa de Câmbio; Mercado de Câmbio; Função de Reação Monetária; América Latina.

ABSTRACT

FREDDO, L. A. M. Inflation Targeting in Latin America: the role of the exchange rate. Dissertation (Master)—School of Economics, Administration, and Accounting, University of São Paulo, São Paulo, 2019.

Several Emerging Market Economies (EME) have adopted Inflation Targeting (IT) as their monetary policy framework in the past decades—generally after a period of some type of a fixed exchange rate policy. Under an IT regime, in theory, the exchange rate should freely float. In fact, monetary authorities should only care about the propagation of secondary effects of exchange rate changes on prices—through demand and/or expectations, but not trying to influence the exchange rate trajectory itself. The reality of EME, however, reveals that the exchange rate is of crucial importance not only for the conduction of monetary policy but also for its effects on the domestic economy, due to their susceptibility and vulnerability to pro-cyclical capital flows. In this vein, this dissertation aims at investigating how exchange rate movements influence interventions in the market of Latin American monetary authorities (Brazil, Chile, and Colombia) through two instruments, that is, through Foreign Exchange (FX) interventions and through short-term interest rate changes, estimating Monetary Reaction Functions (MRF) for the last variable. The main contribution is the incorporation of potential asymmetries—more concerned with currency appreciation or currency depreciation—in the behavior of monetary authorities. Findings shed light on the fact that, although the exchange rate has played a pivotal role for their IT regimes, the utilization of instruments has varied in terms of intensity, purpose, and asymmetry when it comes to exchange rate movements. In Brazil, monetary authorities have asymmetrically behaved towards currency depreciation, with both instruments. In Chile, the asymmetry has been towards currency appreciation, also with both instruments, but FX interventions have been much more modest. In Colombia, monetary authorities have asymmetrically behaved towards currency appreciation in the FX market; no evidence of asymmetry has been found through interest rate changes. The potential reason behind asymmetries is also different: whereas in Brazil monetary authorities have been more concerned about currency depreciation, potentially due to issues regarding their inflation goals, in Chile and Colombia, they have been more concerned about currency appreciation, potentially due to issues regarding their balance of payments. Besides, the intensity and frequency of interventions, especially in the FX market, arise the question, for the cases of Brazil and Colombia, whether monetary authorities have tried to influence somehow the exchange rate trajectory itself.

Keywords: Inflation Targeting; Exchange Rate; FX market; Monetary Reaction Function; Latin America.

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INTRODUCTION

The type of monetary policy adopted by central banks has varied over time, influenced by different economic theories and thinking. The gold standard, for example, was the mainstream regime from 1880 to 1914 in which the central bank had a commitment to the public to ensure convertibility of money into gold at a pre-announced rate. In the aftermath of the gold standard era¹, the attention paid to the exchange rate for the conduction of monetary policy increased, as many central banks used to adopt an exchange rate anchor. In truth, even recently this variable has guided the monetary policy framework in several economies. The IMF (2017) documents that fifty-four members have an officially announced fixed exchange rate policy—such as currency board and conventional peg—highlighting the use of the exchange rate as a nominal anchor.

The past decades, however, have witnessed an increase in the number of economies whose monetary policy is based on inflation targets, especially among Emerging Market Economies (EME)—according to the IMF (2017), there are currently thirty-one EME under Inflation Targeting (IT). First adopted by New Zealand in April of 1988, IT regimes can be characterized by five elements (MISHKIN, 2004): (i) public announcements of inflation targets which will be pursued by monetary authorities in the medium-term horizon; (ii) an institutional commitment to achieve the target as the primary goal of monetary authorities; (iii) a powerful strategy of communication with the public; (iv) high level of transparency to the extent that all the objectives and instruments of monetary authorities need to be known by the public; (v) accountability of monetary authorities for missing/achieving the inflation target.

The first efforts to theorize the economic foundations of an IT regime generally emphasized that the exchange rate should freely float if monetary authorities conducted a monetary policy under IT. This thesis was incorporated in the literature especially after the dissemination of the work of John Taylor (e.g. Taylor (1993), Taylor (2000), Taylor (2001)). The author points out that if a country does not choose a monetary policy based on frameworks such as exchange rate pegs, targets for the monetary base or some kind of dollarization the only remaining alternative, capable of ensuring price stability in the long-run, is the following trinity: (i) a flexible exchange rate; (ii) an inflation target; and (iii) a monetary policy rule. From this perspective, there are two implications with respect to the conduction of monetary policy. Firstly, the interest rate used to conduct monetary policy should respond only to deviations of the inflation from its target and of the output from its potential. Secondly, the exchange rate needs to freely float, without interventions

¹The different reforms and phases that monetary policy has witnessed since the late 19th century are meticulously summarized by Eichengreen and James (2003).

of monetary authorities in order to affect its trajectory.

Taylor (1993), Taylor (2000), Taylor (2001) emphasize that monetary authorities should not publicly compromise themselves to a specific/strict rule as the reality is more challenging than an equation can describe. The author points out, however, that this does not mean that a simple rule, including only the inflation and output gaps, does not describe well actions of monetary authorities. Particularly, he argues that the interest rate used to conduct monetary policy should not respond to exchange rate changes as, by including the output gap, interest rate changes would be already responding indirectly to exchange rate changes, dissipating their effects on prices.

In this vein, a canonical IT regime can be described as a monetary policy framework in which monetary authorities seek to maintain price stability and to anchor expectations in the medium-term horizon, whose monetary policy instrument is the short-term interest rate. By responding to the output gap, monetary authorities would already be offsetting the secondary effects of exchange rate movements on prices. Besides, the exchange rate should freely float without interventions in order to influence the exchange rate trajectory itself. In other words, monetary authorities should only care about the propagation of secondary effects of exchange rate changes on prices—through demand and/or expectations, but not trying to influence directly the exchange rate trajectory.

The reality of EME, however, reveals that the exchange rate is of crucial importance not only for the conduction of monetary policy but also for its effects on the domestic economy. Calvo, Leiderman and Reinhart (1993), for example, already emphasized that the exchange rates in Latin America were susceptible to pro-cyclical capital flows, that is, during episodes of stable financial conditions in the international markets, these economies experienced surges of capital inflows; but during tightened financial conditions, the reverse scenario was rapidly observed, with sharp capital outflows. The pro-cyclical capital flow results in a tendency of exchange rate appreciation during episodes of stable financial conditions and of sharp depreciation in the opposite scenario.

The seminal paper of Calvo and Reinhart (2002) also presents evidence of procyclical capital flow dynamics in EME, affecting the exchange rate behavior, generally in a problematic manner as exchange rate suffers from sharp and very rapidly variations, with disruptive consequences for portfolios, prices, and balance of payments, for example. The authors argue that, due to this particular EME characteristic, many central banks intervened in the market in order to attenuate currency volatility and to curb exchange rate movements, even in cases of IT regimes in which the exchange rate is said to be freely floating, as though there were a "fear of floating". They enumerate several reasons/hypothesis behind the reluctance of EME to tolerate much exchange rate variation, such as liability dollarization, output costs, lack of credibility, and high pass-through from exchange rate to prices.

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More recently, Rey (2015) and Passari and Rey (2015) show evidence that capital flows are more sensitive to the financial cycle originated in the US than to countries' specific macroeconomic conditions. Capital flows exhibit a common pattern across the world: they are pro-cyclical, with surges throughout periods of low volatility and risk aversion, and with outflows when the scenario is the opposite. Passari and Rey (2015) claim that the main consequence of this dynamics is its impact on the autonomy of monetary policy, i.e. there is a dependence of monetary policy conditions outside the US to the policy stance adopted by the Federal Reserve (Fed). This dependence, in other words, may induce central banks to intervene in the market, either through interest rate changes or through Foreign Exchange (FX) market, in order to attenuate the effects of capital flows on the exchange rate, which, in turn, can affect several domestic variables.

There is also evidence that the capital flow cycles have a strong relationship with real commodity price cycles, as documented by Reinhart, Reinhart and Trebesch (2016) with data across approximately two centuries (1815-2015). According to the authors, EME are more susceptible to surges of capital inflows throughout periods of increasing commodity prices. They argue, in truth, that these two cycles exhibit a similar trajectory and peak together. The issue is that the period of bonanza—with capital inflows and increasing commodity prices—generally end with economic crises characterized by increasing international interest rates, collapsing commodity prices, and sharp capital flow reversal.

The exchange rate dynamics in EME, thus, reflects to some extent these susceptibilities and their vulnerability to external shocks. Given that the exchange rate variation has the potential to affect crucial domestic variables, it is not unrealistic to suppose that monetary authorities pay significant attention to its behavior. In Latin America, for example, the pass-through from exchange rate changes to prices can be a considerable component of domestic inflation (see (ALPASLAN; DEMIREL, 2014), (IMF, 2016), (LOURENÇO; VASCONCELOS, 2018)), threatening the achievements of monetary authorities. González (2017) investigates the balance of payment issues in Latin America and concludes that, differently from the reasons behind the "fear of floating" during the 1990's, during the recent commodity boom (2003-2013) the intention was to avoid excessive currency appreciation and to prevent Dutch disease. Put in another way, the "fear of floating" still existed during the commodity boom (2003-2013), but instead of avoiding depreciation, Latin American economies avoided appreciation.

The particularity of the exchange rate for Latin America—and for EME in general has prompted an intense debate regarding the way in which monetary authorities behave towards exchange rate movements when the monetary policy is under IT. Part of the literature has focused on the response of monetary authorities to exchange rate movements through the FX (Foreign Exchange) market (see (BARAJAS *et al.*, 2014), (BERMÚDEZ, 2014), (CÉSPEDES; CHANG; VELASCO, 2014), (GONZÁLEZ, 2017)). The general conclusion is that these economies have intervened more in the market than expected in a canonical IT regime. Another part of the literature has investigated the response of monetary authorities to exchange rate movements through the short-term interest rate (see (MOHANTY; KLAU, 2005), (AIZENMAN; HUTCHISON; NOY, 2011), (BENLIALPER; CÖMERT, 2015)), advocating that the exchange rate is a variable of importance for the decision making-process of monetary policy.

If, on the one hand, the importance of the exchange rate for the conduction of monetary policy in Latin America has been documented in the literature, on the other, issues regarding the connection/differences between monetary authorities interventions through interest rate changes and through the FX market still need to be addressed. Besides, monetary authorities may act asymmetrically towards the exchange rate, that is, exhibiting "fear of appreciation" or "fear of depreciation", an issue not sufficiently analyzed in the literature.

The central objective of this dissertation, therefore, is to help fill the gap with respect to the role of the exchange rate in the context of Latin American economies under IT. In particular, the aim is to investigate how exchange rate movements affect the interventions of monetary authorities in the market, either through FX market or through the short-term interest rate, and to explore potential reasons behind the behavior of monetary authorities towards the exchange rate. The main contribution of this dissertation is the incorporation of potential asymmetries—more concerned with currency appreciation or currency depreciation—in the behavior of monetary authorities, both through FX interventions and through interest rate changes, and the connection/differences between the two.

The countries analyzed here are Brazil, Chile, and Colombia. Apart from the fact that these economies were the pioneers to adopt an IT regime in Latin America, at the end of the 1990's, there are three more reasons why they were chosen. First, as discussed above, they exhibit a similar dynamics of capital flows, which, to some extent, is materialized in the exchange rate. The second reason is related to the fact that these economies present a strong relationship between the prices of their main exports (especially commodities) and the exchange rate. The correlation between the IMF Commodity Price Index and the exchange rate of Brazil, Chile, and Colombia can be examined in Appendix A. Not only the correlations are considerably negative, indicating that an increase in commodity prices is correlated with currency appreciation, but also they depict a very similar trajectory. Third, the analysis was restricted to three economies in order to, on the one hand, be able to compare different economies in Latin America and, on the other, to analyze them in a more profound manner.

The dissertation is divided, beyond the introduction and the concluding remarks, in two parts. Chapter 1 presents the way in which the exchange rate have affected both the achievements and the behavior of monetary authorities in Brazil, Chile, and Colombia, through the analysis of several features such as inflation rate, expectations, interest rate, FX market, exchange rate volatility, and monetary policy reports. Findings suggested that, despite the similar characteristics of these economies and despite the fact that they all target the inflation rate, monetary authorities behavior has varied towards the exchange rate—whereas Brazilian ones have been more concerned with currency depreciation, Chilean and Colombian ones have been more concerned with currency appreciation.

In Brazil, there were several periods with repeated features, namely sharp exchange rate depreciation, exchange rate volatility increase, acceleration of inflation—often very near/above the upper limit interval—, detachment of expectations, monetary policy tightening and FX interventions. Results indicated that monetary authorities have asymmetrically intervened in the FX market, more frequently and intensively during periods of currency depreciation. On the other hand, they have not intervened considerably in the FX market during periods of currency appreciation. A potential explanation for this behavior is the monetary authorities concern with respect to the exchange rate pass-through.

The exchange rate has also played a pivotal role in Chile, but differently from Brazil, periods of intense exchange rate appreciation, detachment of expectations, inflation rate below the lower limit, and monetary policy easing were more frequent. There were cases in which intense currency depreciation influenced the dynamics of domestic prices, but they were not necessarily followed by monetary policy tightening and interventions in the FX market. In truth, Chilean monetary authorities have asymmetrically intervened in the FX market towards currency appreciation, but in a much more modest manner than that of Brazil. Another difference is the potential reason why Chilean monetary authorities have paid more attention to currency appreciation: due to its effects on the balance of payments.

In Colombia, there were periods in which both currency depreciation and currency appreciation were coincident with decrease/increase of inflation, detachment of expectations, and monetary policy easing/tightening. Nevertheless, in terms of why monetary authorities might be concerned with exchange rate movements, the Colombian experience is more similar, but not completely so, to the Chilean one. Colombian monetary authorities have also intervened asymmetrically in the FX market towards currency appreciation, but not only more intensively but also with monetary authorities recognizing more openly their intention to attenuate balance of payments issues.

In Chapter 2, the objective is to comprehend how exchange rate movements influence the short-term interest rate used by central banks as the main policy instrument. First, results of the Granger-Causality test indicated that past values of the exchange rate help predict interest rate changes (causal ordering), for the cases of Brazil and Chile, but the reverse causation—from the interest rate to the exchange rate—does not hold. The test applied to the Colombian variables did not suggest causal ordering in any direction. Second, for each country Monetary Reaction Functions (MRF) with and without asymmetries towards the exchange rate were estimated—an exercise not applied to Latin American economies yet.

Results suggested that the exchange rate has been taken into consideration in the decision making-process of monetary authorities, showing evidence of asymmetry in the cases of Brazil and Chile. In Brazil, estimated equations suggested that monetary authorities have asymmetrically behaved towards the exchange rate, with more concern about currency depreciation, similarly to the behavior observed in the FX market. On the other hand, in Chile, the evidence suggested that monetary authorities have been more concerned about currency appreciation, but also in line with the asymmetrical behavior observed in the FX market. No evidence was found of asymmetry of interest rate changes towards exchange rate changes in Colombia.

Findings of Chapter 2, together with those of Chapter 1, shed light on the fact that, although IT regimes in Latin America have the inflation target in its core, the utilization of instruments (FX interventions and interest rate changes) has varied in terms of intensity, purpose, and asymmetry when it comes to exchange rate movements. In Brazil, monetary authorities have asymmetrically behaved towards currency depreciation, with both instruments, justifying that interventions, mainly in the FX market, aimed at attenuating exchange rate volatility and the propagation of secondary effects on prices. However, due to the intensity and frequency of interventions, and due to the fact that periods in which interventions and monetary policy tightening hardened the most were also coincident with periods of relevant exchange rate pass-through, the question whether Brazilian monetary authorities have also tried to influence the exchange rate trajectory itself, avoiding, for example, excessive currency depreciation, is still open to discussion.

In Chile, the asymmetry has been towards currency appreciation, also with both instruments, but it is worth noting that FX interventions have been much more modest than that of Brazilian and Colombian experiences, weakening the question whether Chilean monetary authorities have tried to influence the exchange rate trajectory. In Colombia, although there was no evidence of asymmetry towards exchange rate movements with interest rate changes, monetary authorities have asymmetrically behaved towards currency appreciation in the FX market, but with intensity and frequency more similar to that of Brazil, also arising the question whether they have tried to influence the exchange rate trajectory.

Summing up, it has been argued in this dissertation that, although the exchange rate is of crucial importance for Latin American economies under IT, the utilization of instruments has varied in terms of intensity, purpose, and asymmetry. Whereas in Brazil monetary authorities have behaved asymmetrically towards currency depreciation,

als in Chile and Colombia, mono

potentially due to issues regarding their inflation goals, in Chile and Colombia, monetary authorities have asymmetrically behaved towards currency appreciation, potentially due to issues regarding their balance of payments.

1 INFLATION TARGETING AND EX-CHANGE RATE IN LATIN AMERICA

The recent history of monetary policy in Latin America has the exchange rate at its core. During the 1990s, most countries had some sort of exchange rate anchor, but, especially in Emerging Market Economies (EME), this regime happened to be very vulnerable to international economic crises and to speculative attacks (such as those that followed Asian, Mexican, and Russian crises), undermining the capacity of monetary authorities in maintaining the anchor¹. In the late 1990s, Brazil, Chile, and Colombia were the first economies in Latin America to let their currencies float and, concomitantly, to adopt an IT regime as their monetary policy framework.

The central objective of this chapter, therefore, is to shed light on the importance of the exchange rate for the conduction of monetary policy in Latin America, even after the adoption of IT regimes. Latin American currencies have floated more freely since the beginning of the 2000s', but that does not mean that monetary authorities do not intervene in the FX market nor that the role played by this variable is restricted to absorbing shocks in the economy. In truth, it will be argued that monetary authorities paid, from 2000 to 2017, significant attention to the exchange rate dynamics, as most episodes of strong currency appreciation/depreciation were coincident with episodes of target missing. In Brazil, monetary authorities intervened in the FX market more frequently throughout periods of currency depreciation, by selling dollars; in Chile and Colombia, on the other hand, monetary authorities intervened more frequently in the other direction, that is, throughout periods of currency appreciation, by purchasing dollars.

1.1 THE BRAZILIAN EXPERIENCE

1.1.1 EXCHANGE RATE AND INFLATION

The IT regime in Brazil has been, roughly speaking, successful in maintaining the inflation rate under control and within the tolerance range stipulated by monetary authorities. However, the analysis of Figure 1 shows clearly two episodes (2001-2003 and 2011-2016) in which not only the inflation rate reached levels above/near the upper limit (graph on the left) but also expectations witnessed a significant departure from the region close to the target (graph on the right). One important factor, though not the only one, that helps understand the acceleration of inflation during these episodes is the exchange rate

 $^{^{1}}$ For a detailed discussion regarding the different exchange rate regimes adopted in Latin America during the 1990s, see (QUISPE-AGNOLI, 2001).

(see, for example, Braga (2013) for the importance of exchange rate changes in explaining the inflation rate during the 2000s). In Figure 2, for instance, it is possible to verify the correlated trajectory between the exchange rate and the CPI, indicating the potential importance of the former to understand the latter. The focus here will be to investigate the relationship among the exchange rate, the inflation rate, and the achievements of monetary authorities.

Barbosa-Filho (2008), in fact, already shed light on the importance of the exchange rate for the comprehension of the Brazilian IT regime, from 1999 to 2006. The author argues that a major part of Brazilian inflation was explained by the exchange rate passthrough, implicating that most of the successes and failures of inflation targeting during the period of his analysis are related to the exchange rate behavior. Here, it will be argued that this characteristic is still relevant to understand both the functioning of IT and the conduct of monetary policy in Brazil.



Figure 1 – Brazilian CPI and Expectations Source: IBGE and Brazilian Central Bank (BCB).

In Table 1, there is a summary of information available in Figures 1 and 2. Besides the two episodes mentioned above, the year of 2008 was included in the analysis for two reasons. First, the global economy witnessed a severe crisis that followed the Lehman Brothers bankruptcy, prompting considerable exchange rate depreciation in several EME (32.8% in nominal terms in Brazil). Second, the analysis of this year, in particular, will be important to comprehend the monetary policy not only in Brazil but also in the remaining countries of the sample (Chile and Colombia).

The first episode in which Brazilian monetary authorities struggled to maintain



Figure 2 – CPI x Exchange Rate

Source: IBGE and Brazilian Central Bank (BCB).

Table 1 – Exchange Rate and Inflation—Brazil

Period	Average Annual Inflation	Exchange Rate Variation
2001-2003	9.8%	Depreciation of 46.6%
2008	5.9%	Depreciation of 32.8%
2011-2016	6.9%	Depreciation of 94.8%

Source: IBGE, Brazilian Central Bank (BCB) and author's calculation

the inflation rate below the upper limit and to anchor expectations (see Figures 1 and 2) happened at the beginning of the IT regime. Of course, the implementation of a new monetary policy requires time for both monetary authorities and economic agents to understand and to get used to it. On the one hand, monetary authorities need to understand how their new tools and interventions will impact not only monetary policy itself but also how they will propagate to the different spheres of the economy. Economic agents, on the other, need to understand and interpret how this mechanism works. If the Brazilian IT beginning had only dealt with these matters, it would have been difficult to monetary authorities, but easier than it was.

The Brazilian economy was hit by several shocks from 2001 to 2003 (MINELLA *et al.*, 2003), but the exchange rate was the main factor explaining the outcomes in terms of inflation. As seen in Table 1, the 2001-2003 period exhibit the highest average annual inflation (9.8%) and the exchange rate depreciated 46.6% in nominal terms. Brazilian monetary authorities ((FRAGA, 2002) and (MEIRELLES, 2003)) estimated, for example, that 38% of the annual inflation (7.67%) in 2001 and 46.4% of the annual inflation (12.53%) in 2002 was due to the pass-through from exchange rate changes to prices. This reflects, in other words, how important was the exchange rate behavior in explaining the inflation rate during the first episode in which the inflation target was not met.

In 2008, there was another expressive depreciation of the Brazilian Real—32.8% in nominal terms (see Table and Figure 1). The Lehman Brothers bankruptcy in September prompted a real catastrophe in financial markets around the world and the consequences were harmful to EME, even with the policy measures taken by them (DOOLEY; HUTCHI-SON, 2009). Despite the significant depreciation of the real, the inflation rate was kept within the tolerance range and the expectations did not deviate considerably from the target (see Figure 1), but the (BCB, 2008) made clear that monetary authorities were vigilant with regard to the lagged effects arising from the currency depreciation after the crash of September. Monetary policy in Chile and Colombia, as will be argued later, was not as successful as that of Brazil during the turmoil of 2008; these countries, for example, witnessed a higher exchange rate pass-through and an inflation rate outside the tolerance range.

The scenario from 2011 to 2016² is characterized by a continuous currency depreciation, a persistent detachment of expectations from the target and a rising inflation. The Real began to lose value against the dollar in 2011 and depreciated every year from 2011 to 2016 (see Figure 2), accumulating a depreciation of 94.8% in nominal terms in the period (see Table 1). The reasons behind this turning point observed in the Brazilian currency were related to the end of the Commodity Boom that started at the beginning of the 2000s (ERTEN; OCAMPO, 2013), but also to the less favorable international environment whose consequences are generally materialized in the exchange rate and in the dynamics of capital flows of EME ((REY, 2015) and (PASSARI; REY, 2015)). In reality, Reinhart, Reinhart and Trebesch (2016) argue that capital flow cycles and real commodity price cycles are strongly correlated, depicting similar trajectories and peaks, but generally ending with a crisis, especially in EME.

If, on the one hand, the inflation rate remained most of the time within the target limits, even with the currency depreciation observed since 2011, on the other, from 2011 to 2016, the inflation rate remained in the upper half of the tolerance range, and not occasionally near the upper limit (see graph on the left of Figure 1). In fact, this was incorporated to some extent by economic agents, as the expectations detached persistently from the target (see graph on the right of Figure 1). The most critical result came in 2015, when the annual inflation rate reached 10.7% and the real depreciated 47%, a level only lower than that of 2002. Similarly to the explanation given for the inflationary scenario of 2001-2003, monetary authorities ((TOMBINI, 2016) and (BCB, 2015b)) emphasized that the sharp depreciation not only had effects on inflation dynamics in the short-term but also in the medium-term through expectations. They estimated that the exchange rate pass-through represented 14.7% of the annual inflation in 2015 which complicated the

²Other factors also help to explain the inflation dynamics from 2011 to 2016, as the services inflation behavior. See, for example, the additional section in the Inflation Report of 2015 (BCB, 2015b) and the study of (AMITRANO *et al.*, 2018)

achievement of the target.

It is worth noting that in 2017 the inflation rate also stayed out of the tolerance range, but this time below the lower limit due to a supply shock. In contrast with the episodes in which the inflation rate remained near/above the upper limit, neither the exchange rate pass-through was an important factor nor monetary authorities considered it as a big problem. Goldfajn (2018), then president of the Brazilian Central Bank (BCB), points out that the low price level revealed the supply conditions with a massive agricultural production, reflected on food prices, which suffered a deflation of 4.95% in 2017.

The analysis of the relationship between the exchange rate and the inflation rate in Brazil suggests that, from 2000 to 2017, periods of (strong) currency depreciation were coincident with those of inflation rate close to or above the upper limit, potentially due to the pass-through. On the other hand, periods of (strong) currency appreciation did not witness inflation rate below the lower limit. In reality, with the exception of 2017, during periods of currency appreciation the inflation rate remained within the tolerance range.

The literature has documented a potential asymmetry of the exchange rate passthrough. Modenesi, Luporini and Pimentel (2017) estimated an SVAR with the exchange rate decomposed into currency appreciation and depreciation. The authors find that there is an asymmetric exchange rate pass-through in Brazil; the estimated pass-through after currency depreciation is of 16%, whereas after currency appreciation, 5.8%, that is, a currency depreciation will not be offset by an appreciation of same magnitude. The same asymmetric pass-through towards depreciation has been found by Lourenço and Vasconcelos (2018)—a result consistent with the analysis made here and in the same direction pointed out by the Monetary Reaction Function (MRF) estimated in Chapter 2, i.e., Brazilian monetary authorities respond, through interest rate changes, asymmetrically to exchange rate variations, paying more attention to cases in which the currency depreciates. This means that the way in which monetary authorities respond through interest rate to exchange rate variations is different, more prominent during episodes of currency depreciation.

In short, the Brazilian IT regime reveals that the exchange rate influenced significantly the inflation behavior and the achievements of monetary authorities over the 2000-2017 period. In particular, the years in which the inflation rate did not remain within the tolerance range were characterized by persistent detachment of expectations from the target and by strong currency depreciation, suggesting a potential importance of the pass-through in order to explain, to some extent, the acceleration of inflation. On the other hand, the inverse scenario—periods of strong currency appreciation—was not associated with years of inflation rate outside the tolerance range. In truth, all the years in which monetary authorities did not meet the target were years of exchange rate depreciation, with the exception of 2017.

1.1.2 EXCHANGE RATE AND INTEREST RATE

Given that the exchange rate has considerably influenced the behavior of inflation, especially during periods of depreciation, one may ask how/whether the interest rate has responded to this variable or, in other words, if the episodes of exchange rate depreciation and inflation near/above the upper limit were coincident with monetary policy tightening. Figure 3 has two graphs that helps investigate the question; the graph on the left shows the interest rate and the exchange rate trajectories and the graph on the right, the interest rate and the CPI trajectories. In both of them, the shaded areas correspond exactly to the three episodes described in Table 1.



Figure 3 – Brazilian Exchange Rate, Interest Rate and CPI Source: IBGE and Brazilian Central Bank (BCB).

The graph on the right highlights an expected characteristic of the IT regime, that is, the periods in which the inflation rate increases coincide with monetary policy tightening; the shaded areas depict both increasing inflation rate and cycles of interest rate increase. The only exception was the beginning (2011-2012) of the third one when, despite the fact that the inflation rate began to be very close to the upper limit, the Selic rate decreased from 12.5% to 7.25%. However, from 2013 to 2016, this rate witnessed an increase to 14.25%.

The analysis of the graph on the left, in turn, permits to see another characteristic: most of the episodes of monetary policy tightening occurred during episodes of exchange rate depreciation. In particular, the shaded areas show that the three episodes of intense exchange rate depreciation were followed by cycles of interest rate increase (which can also be verified through a Granger Causality test that is shown in Chapter 2, suggesting that the exchange rate helps to predict the interest rate). For example, during the 2001-2003 episode, when the exchange rate suffered a sharp depreciation, the Selic rate had two cycles of increase: in 2001, when it was raised from 15.25% to 19.0%; and from 2002 to 2003, when it was raised from 18.8% to 26.5%. Similarly, from 2013 to 2016, when the exchange rate depreciated persistently each year, the Selic rate was raised from 7.25% to 14.25%.

The relationship between the exchange rate and the interest rate is also documented by the literature. Silva and Bresser-Pereira (2008) argue that there is an exchange rate/interest rate trap in the Brazilian IT regime: because a major part of the inflation rate is due to exchange rate variations, interest rate increases has been used in order to attenuate the pass-through. Similarly, Serrano (2010) emphasizes that in truth the inflation rate comes from cost-push and, as a result, monetary policy is generally successful when interest rate increases are capable of preventing currency depreciation. This interpretation seems to be partially correct, given the exchange rate importance for the dynamics of prices in Brazil and the interest rate response during periods of depreciation. However, as will be argued in the next subsections, monetary authorities can intervene directly in the FX market, not necessarily having to increase the interest rate.

The fact that interest rate increases have mostly occurred during years of accelerating inflation and of detachment of expectations is expected from the IT regime perspective, but Figure 3 reveals that currency depreciation was also a recurrent feature throughout these episodes, suggesting that part of the monetary policy tightening is due the exchange rate variation.

1.1.3 FX INTERVENTIONS

The Brazilian case is one in which monetary authorities have considerably intervened in the FX market. Figure 4 shows four important variables to understand the FX interventions. First, the Foreign Exchange Swap Balance³ (stock of FX swaps, that is, positive values represent dollar future sale and negative ones, purchase). Second, Foreign Exchange Sale with Repurchase (it represents a spot dollar sale with guarantee of repurchase by the BCB). Third, Foreign Reserves in dollars. Four, the exchange rate volatility⁴.

The first characteristic that is worth noting to understand the FX interventions is the international reserves under monetary authorities' control. Without them, the capability of monetary authorities to intervene in the FX market would be very restricted. Over the 2000-2017 period, Brazilian monetary authorities accumulated international reserves, coming from U\$ 32.4 to about U\$ 374 billion dollars (see Figure 4). This pattern of accumulation was also observed in Chile and Colombia, as their international reserves depicted a similar trajectory of accumulation (see Figures 8 and 12, respectively).

 $^{^{3}}$ An FX/currency swap is a financial derivative from which the BCB compromises to pay the swap's owner the exchange rate variation and, in turn, the BCB receives the interest rate variation. The FX swap helps protect its owner from currency depreciation and it can serve as a hedge.

⁴The volatility is calculated as $E\left\{\left|\frac{e_t-e_{t-1}}{e_{t-1}}\right|*100\right\}$ for a 60 months rolling window, that is, the average of the percentage variation of 60 months.



Figure 4 – Brazilian FX Interventions

Source: Brazilian Central Bank (BCB) and author's calculation.

With respect to the interventions, the Foreign Exchange Sale with Repurchase was used by the BCB only during periods of tightened financial constraints, when the market demanded liquidity, whereas the Foreign Exchange Swaps became a regularly derivative used by the BCB. The periods, for instance, in which the BCB sold dollar through the former option embody episodes of sharp and/or strong depreciation trend, but the quantity of dollars sold is relatively small (at most US\$ 10 billion). On the other hand, the utilization of FX swaps in order to intervene in the FX market was present throughout almost the entire IT regime, especially during exchange rate depreciation episodes, having their stock already peaked US\$ 112 billion.

When the Brazilian currency experimented a strong depreciation in 2002-2003 and an increase in its volatility⁵, the stock of FX swaps reached about US\$ 40 billion (representing sales). Likewise, in the aftermath of the Lehman Brothers crash, in 2008, when the real experienced a significant depreciation against the dollar (32.8% in nominal terms), monetary authorities intervened in the FX market and changed very rapidly the swap stock from a negative value of US\$ 22 billion (representing dollar purchase) to a positive value of almost US\$ 12 billion (representing dollar sales).

However, it was after 2013 that the intervention through swaps became more frequent and persistent. As the Real began to depreciate and its volatility to increase,

⁵Note that the graph of exchange rate volatility has a 60 months rolling window. So, the highest historical volatility observed in the graph, during 2005, is due to the years of 2002 and 2003.

the stock of swaps became not only positive but also achieved its highest value, standing at US\$ 112 billion. The interventions through Foreign Exchange Sale with Repurchase also occurred in the period, but the amount of dollars sold was much smaller and not as frequent as the interventions through swaps. Of course that they are different, while one represents dollar sale in the spot market and the other represents a dollar sale in the derivatives market (i.e., future sale), but the point is that the stock of FX swaps was disproportionally bigger.

There are, at least, two potential explanations for this monetary authorities' behavior. Firstly, it can be a policy choice. Foreign Exchange Sale with Repurchase represents an intervention in the spot market through which the BCB needs to use international reserves. On the other hand, with FX swaps, the BCB intervenes in the future market without using international reserves. Secondly, the fact that FX swaps were used more frequently and intensively can be related to the own nature of Brazilian market, given that FX swaps help stabilize financial and speculative flows and can give protection for currency depreciation.

Rossi (2015), for example, argues that the Brazilian exchange rate is very susceptible to speculative attacks, especially coming from the derivatives market. In fact, the author emphasizes that the liquidity of futures market is higher than that of spot market, which makes the former a significant determinant of the current exchange rate, that is, the future market is one of the main factors in the determination of the exchange rate trend and volatility. In this vein, FX swaps can be used to attenuate these problems without using international reserves.

It is worth noting that the periods in which Brazilian monetary authorities intervened in the FX market the most coincide with periods of high inflation, of detachment of expectations from the target, and of interest rate rise, as in 2002-2003 and in 2013-2015. Put in another way, the experiences of sharp/strong currency depreciation and high volatility in Brazil have been characterized by similar pattern with respect to inflation behavior, expectations and monetary authorities' response, either through interest rate or FX market intervention.

The monetary authorities' response through the FX market during exchange rate appreciation episodes has not necessarily followed the inverse track. For example, when the Real appreciated considerably after the crisis of 2008, there was no intervention in the FX market from July 2009 to December 2010, but, at the same time, the Real was near its lowest parity with the dollar (USD/R\$ 1.50). This reflects, in other words, a greater concern of Brazilian monetary authorities towards currency depreciation. The asymmetry is particularly clearer after 2013, when the Real began to depreciate persistently until 2016 and the stock of FX swaps also increased, following the depreciation trend (see Figure 4).

If the number of monthly FX swaps interventions was considered only outside the

interval of the mean plus/minus one standard deviation (i.e., $\mu \pm \sigma$, see Appendix B)⁶, 62.3% of them would exceed the upper bound interval, indicating an asymmetry towards currency depreciation. This reflects not only that monetary authorities, from 2000 to 2002, intervened more frequently during periods of depreciation but also more intensively as there were more interventions that exceeded the upper bound interval.

The special attention to the FX market, in order to better understand the functioning of IT regimes in EME, is also paid by a considerable part of the literature. Bermúdez (2014) investigates the pattern of FX interventions in Latin America and argues that Brazil can be characterized as a "heavy intervener". By analyzing the frequency and the amount of interventions (as a ratio to GDP), the author argues that interventions have occurred with discretionary. The research carried out by Carrera (2015) also analyzes the exchange rate management in Latin America and, once again, Brazil is among the countries in which there is evidence of exchange rate misalignment with respect to the long-run equilibrium, which implies a deviation from the freely floating regime.

Some economists go even further by arguing that Brazilian monetary authorities have pursued a specific objective towards the exchange rate. Céspedes, Chang and Velasco (2014), for example, emphasize that FX interventions are widespread in Brazil, beyond what is expected from a pure flexible exchange rate regime, reflecting the fact that this variable has become a target of policy. Similarly, Barajas *et al.* (2014) point out that in Brazil there is a "fear of depreciating" and, because of that, monetary authorities have specific objectives towards the exchange rate, having used FX market interventions to attain them.

Although it may be difficult and complicated to support and verify the hypothesis that monetary authorities have a specific objective towards the exchange rate, the FX market analysis shown here, in line with the main findings of the literature, indicates that the FX interventions have been occurring more frequently and intensively than what is expected from a conventional IT regime. The explanation behind this behavior may be related to the exchange rate pass-through and to the high exchange rate volatility during periods of depreciation.

1.1.4 EXCHANGE RATE AND MONETARY AUTHORITIES

The interventions of Brazilian monetary authorities in the market, since the IT adoption, have mostly occurred through two instruments: the interest rate (the conventional way for an IT regime) and the FX interventions⁷. The first instrument generally responds

 $^{^6\}mathrm{By}$ doing this, the intervention asymmetry does not consider small interventions nor those close to the mean.

⁷In practice, monetary authorities can intervene, directly and indirectly, in the market in several ways in order to affect the exchange rate. For example, from 2011 to 2013, there was a financial tax that attenuated the exchange rate depreciation ((CAGNIN *et al.*, 2013) and (ROSSI, 2015)). The attention
to changes in the output gap and in inflation expectations. Given the importance of the exchange rate in the dynamics of inflation, it is not unrealistic to suppose that monetary authorities also react to changes of this variable. The analysis of Figure 3 indicates that periods of exchange rate depreciation are characterized by monetary policy tightening—which reinforces the results presented in Chapter 2 (Brazilian monetary authorities consider asymmetrically exchange rate changes in their decision-making process, paying more attention to depreciation).

The second instrument represents a more direct way to affect the exchange market. Likewise, it was argued that Brazilian monetary authorities have considerably and asymmetrically intervened in the FX market, towards periods of depreciation. Monetary authorities may try to counteract the exchange rate shock itself (avoiding, for example, the depreciation and, to some extent, to influence the exchange rate level) or to counteract the propagation of the shock (avoiding excessive volatility). In this subsection, therefore, the aim is to expose how monetary authorities, through their main vehicles of communication, talk about the exchange rate, that is, how they refer to the exchange rate and how they justify the interventions in light of exchange rate variations.

The first relevant feature present in Brazilian Inflation Reports and in the Open Letters⁸ suggests that monetary authorities recognize the exchange rate pass-through as one of the most important factors in explaining the inflation rate during years that the target was not met. Secondly, the justification of their interventions, either through the interest rate or through the FX market, is based on the argument of avoiding the propagation of the shock for the medium-term horizon and of attenuating exchange rate volatility.

During the 2001-2003 episode, in which the inflation rate reached levels well above the target and the expectations detached considerably from the target, monetary authorities emphasized that the exchange rate depreciation was one of the main factors in the outcome.

> Inflation ended the year above the established target due to external and internal shocks that hit the Brazilian economy in 2001. On the external front, the slowdown in the world economy, the contagion from the Argentine crisis and the terrorist attacks in the United States produced strong depreciation pressure of the real in 2001. In October, the real's price reached a peak of R\$2.84 per dollar, accumulating a depreciation of 42.6%. The appreciation of the exchange rate in the last two months of the year allowed the 12-month accumulated average depreciation through December to be 20.9%. This depreciation of the real pushed domestic prices significantly.⁹ (FRAGA, 2002, p. 2) (own translation)

here, however, was paid to the instruments used the most by monetary authorities.

⁸This is an official document in which the president of the Brazilian Central Bank (BCB) needs to address a letter to the Minister of Finance, explaining the reasons why the inflation target was not met.

⁹"A inflação encerrou o ano acima da meta estabelecida em razão dos choques externos e internos que atingiram a economia brasileira em 2001. No âmbito externo, a desaceleração da economia mundial, o contágio proveniente da crise argentina e os ataques terroristas nos Estados Unidos produziram forte

Similarly, the Open Letter regarding the outcome of 2002 explain that the target missing was due to the exchange rate depreciation and to the deterioration of inflation expectations.

The difficulties faced by the country were mainly reflected on the exchange rate and inflation expectations. The sharp depreciation of the exchange rate and the deterioration of inflation expectations had strong impacts on inflation, prompting the non-compliance with the inflation target for $2002.^{10}$ (MEIRELLES, 2003, p. 2) (own translation)

When it comes to the action of the BCB, i.e. the interventions, monetary authorities generally argue that the intention is to prevent the propagation of the exchange rate shock. Besides, they stress that some other measures are used in order to complement the interest rate increase, such as elevation of compulsory rates and FX interventions.

> In 2001, the Central Bank acted in a preventive manner in order to reduce the potential inflationary effects of the new trajectories of the exchange rate and monitored prices — in particular, to avoid the propagation of the shocks. ¹¹ (FRAGA, 2002, p. 5) (own translation)

> The exchange market exhibited in some moments unstable trajectories, especially after the September attacks. In response, the Central Bank opted to complement the interest rate policy with an increase in the percentage of compulsory term deposits and a period of intervention in the foreign exchange market, with satisfactory results.¹² (FRAGA, 2002, p. 6) (own translation)

The second Brazilian experience, over the IT period, with sharp exchange rate depreciation happened in 2008. Differently from the other two cases, the inflation target was achieved and expectations did not detach from the target considerably. Still, the BCB (2008) made clear that monetary authorities were vigilant with regard to the lagged effects arising from the currency depreciation after the crash of September. In particular, they argued that the intervention in the FX market had the objective to ensure liquidity to the market, without attempting to pursue any desired level for the exchange rate.

pressão de depreciação do real em 2001. Em outubro, a cotação do real atingiu o pico de R\$ 2,84 por dólar, acumulando uma depreciação de 42,6%. A apreciação da taxa de câmbio nos últimos dois meses do ano permitiu que a depreciação média acumulada em 12 meses até dezembro fosse de 20,9%. Essa depreciação do real pressionou significativamente os preços internos."

¹⁰"As dificuldades enfrentadas pelo País se refletiram principalmente sobre a taxa de câmbio e as expectativas de inflação. A depreciação acentuada da taxa de câmbio e a deterioração das expectativas de inflação tiveram fortes impactos sobre a inflação, levando ao descumprimento da meta de inflação para o ano de 2002."

¹¹"Em 2001, o Banco Central atuou de maneira preventiva com o objetivo de reduzir os potenciais efeitos inflacionários das novas trajetórias da taxa de câmbio e dos preços administrados por contrato – em particular, para evitar a propagação dos choques."

¹²"O mercado de câmbio exibiu em alguns momentos trajetórias instáveis, especialmente após os atentados de setembro. Como resposta, o Banco Central optou por complementar a política de juros com uma elevação do percentual do recolhimento compulsório sobre depósitos a prazo e com um período de intervenção no mercado cambial, com resultados satisfatórios."

The impact of the reversal of the international economic scenario on the credit channel prompted the Central Bank to act in the foreign exchange market in order to adjust the liquidity conditions in foreign currency. In this context, spot market intervention summed US\$ 1.7 billion in November, but it did not signal any change in the monetary authority's position of not influencing the trajectory nor defining floors or ceilings for the nominal exchange rate. ¹³ (BCB, 2008, p. 97) (own translation)

If, on the one hand, in 2008 the depreciation did not have a strong impact on inflation, on the other, from 2011 to 2016, the continuous depreciation affected the outcome of monetary authorities. In 2015, the year in which both the inflation rate and the exchange rate peaked, Tombini (2016) pointed out that one of the main reasons why the BCB failed to maintain the inflation rate within the tolerance interval was the strong exchange rate depreciation. Besides, he highlighted, as Brazilian monetary authorities did during the two previous episodes, that the monetary policy should try to avoid the propagation of secondary effects of exchange rate shocks.

In 2015, the relative price adjustments represented by the strengthening of the US dollar and by the increase in monitored prices created important challenges to the conduct of monetary policy. These price adjustments prompted inflation to rise in 2015, requiring determination and perseverance to prevent its transmission to longer terms. While acknowledging that these relative price adjustments had direct impacts on inflation, the Central Bank reaffirms its view that monetary policy can contain the second-order effects on inflation. ¹⁴ (TOMBINI, 2016, p. 12) (own translation)

The analysis of the official vehicles of communication of Brazilian monetary authorities with the public reveals two important points with respect to the exchange rate. First, they acknowledge the importance of the exchange rate for the inflation behavior, particularly because the pass-through during years of considerable depreciation played a decisive role in their achievements. Second, the measures taken by monetary authorities regarding the exchange rate are generally justified in light of the argument that they try to avoid the propagation of the shock for longer terms. Put in another way, monetary authorities argue that their interventions, either through interest rate or through market operations, have the objective to avoid the exchange rate shock propagation and to attenuate the exchange rate volatility.

¹³"O impacto da reversão do cenário econômico internacional sobre o canal do crédito motivou a atuação do Banco Central no mercado de câmbio, visando adequar as condições de liquidez em moeda estrangeira. Nesse contexto, as intervenções de venda no mercado a vista, totalizaram US\$ 1,7 bilhão em novembro, sem, contudo, sinalizar nenhuma alteração na postura da autoridade monetária de não influenciar a trajetória nem definir pisos ou tetos para a taxa de câmbio nominal."

¹⁴"Em 2015, os ajustes de preços relativos representados pelo fortalecimento do dólar norte-americano e pelo aumento dos preços administrados criaram importantes desafios à condução da política monetária. Esses ajustes de preços fizeram com que a inflação se elevasse em 2015, necessitando de determinação e perseverança para impedir sua transmissão para prazos mais longos. Ao tempo em que reconhece que esses ajustes de preços relativos tiveram impactos diretos sobre a inflação, o Banco Central reafirma sua visão de que a política monetária pode conter os efeitos de segunda ordem deles decorrentes."

1.1.5 MONETARY AUTHORITIES' BEHAVIOR TOWARDS THE EXCHANGE RATE: WHAT THEY SAY AND WHAT THE DATA SAY

The IT regime in Brazil has shown a particular relationship with the exchange rate. During periods of sharp/strong depreciation, several characteristics have been repeated, such as exchange rate volatility increase, acceleration of inflation—sometimes beyond the upper limit of the tolerance range—, detachment of expectations, monetary policy tightening and FX interventions, especially through FX swap operations. Two characteristics, in reality, represent the direct participation of monetary authorities in the market: through interest rate changes (the conventional IT policy) and through FX interventions.

On the one hand, Brazilian monetary authorities have justified their behavior towards the exchange rate through two main arguments. First, they have argued that, especially during episodes of exchange rate depreciation, interest rate rises aim at, beyond the traditional objective with respect to the inflation target, avoiding the secondary effects and the propagation of the exchange rate shock to domestic prices and to expectations. Second, they have argued that interventions in the FX market are made with the intention to attenuate exchange rate volatility.

On other hand, the analysis of the data suggested that periods in which monetary authorities intervened in the FX market the most were also coincident with periods in which the exchange rate pass-through was a relevant component of the inflation rate outcome—generally near/above the upper limit. In this vein, the remaining question is whether Brazilian monetary authorities, from 2000 to 2017, have intervened in the FX market only in order to attenuate the propagation of exchange rate shocks (i.e., avoiding the propagation into inflation expectations and avoiding excessive exchange rate volatility) or, besides that, in order to influence somehow the exchange rate trajectory itself (i.e., avoiding currency depreciation and its pass-through).

Because the FX interventions have occurred during periods in which both the exchange rate volatility and the pass-through were more intense, and due to the degree of Brazilian monetary authorities' intervention in the FX market, it is hard to separate to which one of the phenomena Brazilian monetary authorities were trying to respond. Understanding this issue in a more accurate manner would help understand better the own functioning of monetary policy in Brazil. Here, it was argued that interventions in the market, both through interest rate—as will be exposed in Chapter 2—and through the FX market have been asymmetrical, occurring more frequently and intensively during periods of currency depreciation, but further research would help clarify the reasons behind Brazilian monetary authorities' interventions, especially through the FX market.

1.2 THE CHILEAN EXPERIENCE

1.2.1 EXCHANGE RATE AND INFLATION

The dynamics of prices in Chile has exhibited, since the IT beginning, a low trajectory for an emerging economy—the annual inflation averaged 3.26% from 2000 to 2017, while for Brazil and Colombia the average was, respectively, 6.50% and 5.09%. Despite the relative low inflation level, Chilean monetary policy has dealt with similar issues to attain the target—periods in which the inflation rate remained outside the tolerance range were also coincident with periods of strong exchange rate variation. There are three periods (2003-2004, 2008-2009, and 2014-2015) in which the inflation rate stayed outside the tolerance range and, at the same time, expectations detached from the target for a while (see Figure 5). The exchange rate influenced the outcomes of monetary authorities both during episodes of appreciation and depreciation (see Figure 6) and Chile is the only economy analyzed here that experienced two deflationary processes under the IT regime.

The beginning of the 2000s was characterized by a new commodity cycle (ERTEN; OCAMPO, 2013) and, as occurred in several EME, the Chilean currency began to strengthen, showing an appreciation trend against the dollar (see Figure 6). The impact of the exchange rate trend on prices was to some extent felt in 2003, when the inflation rate (1.09%) remained below the lower limit, but it was even stronger at the beginning of 2004, as the annual inflation rate became negative (-0.8% in Mars 2004). For the 2003-2004 period, as seen in Table 2, the average annual inflation was 1.8% and the Chilean peso appreciated 20.3% in nominal terms. The BCCh (2004) estimated, for instance, that the peso appreciation reduced the annual CPI by 1 p.p., which represents more than 30% of the annual target. From this first episode, two findings can be drawn: the pass-through from exchange rate changes to prices is also significant in Chile when there is an appreciation; and annual inflation rate can be negative—a scenario not observed in Brazil nor in Colombia.

Table 2 – Exchange Rate and Inflation—Chile

Period	Average Annual Inflation	Exchange Rate Variation
2003-2004	1.8%	Appreciation of 20.3%
2008	7.2%	Depreciation of 30.1%
2009	-1.6%	Appreciation of 22.8%
2014-2015	4.5%	Depreciation of 33.0%

Source: Banco Central de Chile (BCCh) and author's calculation.

The second Chilean experience¹⁵ with annual inflation rate outside the tolerance range and with detachment of expectations from the target happened in the 2008-2009

¹⁵The annual inflation rate at the end of 2007 was 7.75%, but expectations did not detach significantly from target, only as of 2008. Besides, the determining factor of this result was food inflation, which was strongly affected by international food prices and by Chilean frosts that restrained the domestic supply (BCCH, 2008).



Figure 5 – Chilean CPI and Expectations

Source: Banco Central de Chile (BCCh).



Figure 6 – CPI x Exchange Rate—Chile

Source: Banco Central de Chile (BCCh).

period. The international crisis of 2008 prompted the same consequences observed in EME (DOOLEY; HUTCHISON, 2009) for Chile and, initially, generated a sharp and strong currency depreciation (30.1% in nominal terms, see Table 2). The short-term effect was a considerable pass-through from exchange rate changes to domestic prices and the annual inflation rate (7.20%) stood above the upper limit. On the other hand, the Chilean peso experienced a strong appreciation (22.8% in nominal terms) from 2008 to 2009, changing the direction of the pressure, that is, the exchange rate variation began to make

a downward pressure on domestic prices. The BCCh (2009) emphasized that the sharp exchange rate variation, both during its sharp depreciation and appreciation, was one of the main factors in explaining the inflation rate during this period.

As a result, the inflation rate in Chile reversed from a peak of 10.02% in October 2008 to a bottom of -2.49% in November 2009. It is worth noting that the inflation rate in Chile during the 2008-2009 period was also affected by the changes in the international prices of commodities (see (BCCH, 2009)), especially of fuel. The point is that, among several factors that affected the behavior of prices, during episodes of inflation rate out of the tolerance range and, concomitantly, detachment of expectations, the exchange rate always played a determining role in the result.

The story was not much different in the period from 2014 to 2015, when the Chilean currency continuously depreciated (see Figure 6), losing 33.0% of its value in nominal terms against the dollar, which was greatly reflected in domestic prices — inflation rate stood above the upper limit since April 2014 (see the graph on the left of Figure 5). The peso depreciation, according to BCCh (2015), was the main determinant of inflation during 2014 and 2015 as the pass-through was considerably high for CPI components directly affected by the exchange rate changes, as tradable goods, but also for CPI components indirectly affected, as services. Besides, Chilean monetary authorities emphasized that neither central bankers nor economic agents had incorporated correctly the exchange rate pass-through in their forecast, as both of them underestimated it.

The magnitude of the pass-through in Chile, in fact, is still a point of debate in the literature. Mujica and Saens (2015), through quarterly data from 1986 to 2009, estimate the coefficient of exchange rate pass-through to headline inflation for two periods: (i) during the 1990's, when Chilean monetary authorities had already adopted inflation targets, but the exchange rate was still under bands; (ii) during the 2000's, when the inflation targets were adopted with a flexible exchange rate regime. They find that in the first case the pass-through decreased considerably, but the liberalization of the exchange rate as of 2000, even with the inflation target as the nominal anchor, increased significantly the pass-through, suggesting that its magnitude depends on the inflationary environment (i.e., during periods of imbalances, the exchange rate pass-through tends to be higher, as observed in Chile in 2008-2009, 2011-2012 and 2014-2015).

The results of Sansone and Justel (2016) show that the exchange rate pass-through is lower after the IT adoption. With a VAR model, including monthly data from 1987 to 2013 of domestic energy, food and core consumer prices, the authors conclude that not only the pass-through is lower but also more stable since 2002. On the other hand, Alvarez, Jaramillo and Selaive (2012), by disaggregating import prices into border and wholesale levels with monthly data from 1996 to 2007, find that the exchange rate pass-through is complete and nondeclining in the long run at both pricing levels. With respect to the hypothesis of an asymmetric pass-through, the findings in the literature for Chile are not conclusive either. Whereas Alvarez, Jaramillo and Selaive (2012), for example, find weak evidence of an asymmetric exchange rate pass-through, Lourenço and Vasconcelos (2018) estimate that in the long run appreciation tends to lower inflation more than depreciation tends to increase it.

If, on the one hand, the completeness and the asymmetry with respect to the exchange rate pass-through to domestic prices remain an issue not unraveled in the literature, on the other, the evidence suggests that, even assuming the hypothesis of an incomplete and lower pass-through after the IT implementation, movements in the exchange rate are capable of considerably increasing/decreasing the inflation rate—and beyond the tolerance interval set by monetary authorities. It is not uncommon, in truth, to have inflation target missing in Chile associated, to a great extent, with strong currency appreciation/depreciation.

The Chilean experience from 2000 to 2017 with IT regime sheds light on the fact that the exchange rate remains an important source of inflationary pressure even in the case of an emerging economy in which the inflation rate level compares to that of developed economies (Chilean average annual inflation rate during the analyzed period is 3.26%). Similarly to the Brazilian case, the periods in which the inflation rate stayed outside the tolerance range and, simultaneously, expectations detached from the target were coincident with periods of strong/sharp exchange rate variation. The particularity was that the Chilean case witnessed periods of strong currency appreciation with inflation rate below the lower limit—or even deflationary processes—, a feature not observed in Brazil, nor in Colombia.

1.2.2 EXCHANGE RATE AND INTEREST RATE

Except for the 2014-2015 episode, when the Chilean peso depreciated about to 33.0% in nominal terms and the inflation rate stood above the upper limit for more than a year, the conduction of monetary policy followed the expected path. During the 2003-2004 period—the first one that Chilean monetary authorities faced not only inflation rate below the lower limit but also a deflationary process—the Monetary Policy Rate (MPR) was decreased 1 p.p., from 2.75% in November 2003 to 1.75% in February 2004 (see the first shaded area in Figure 7). The particularity, of course, is not the decrease of MPR due to the deflationary scenario observed at the beginning of 2004, but the fact that the currency appreciation was a determining factor in the inflation rate, indicating that movements in the exchange rate can be predictive of interest rate changes.

The combination of strong exchange rate variation, inflation rate out of the tolerance range, and interest rate change was even more intense during the 2008-2009 episode (see the second shaded area in Figure 7). The monetary response to the two extremes—i.e., (i)



Figure 7 – Chilean Exchange Rate, Interest Rate and CPI Source: Banco Central de Chile (BCCh).

depreciation of 30.1% and inflation rate of 7.2% in 2008 and (ii) appreciation of 22.8% and inflation rate of -1.6% in 2009—was perceived in the interest rate change, though with different variations. In 2008, there was a variation of 2 p.p. in the MPR, increasing from 6.25% in May 2008 to 8.25% in October 2008, but remaining at this last level for the rest of the year. However, as of January 2009, the MPR began to decrease very rapidly, achieving its lowest historical level (0.5%) already in August 2009, representing a variation of -7.75 p.p.

The analysis of the Chilean inflation from 2008 to 2009, in other words, revealed that not only the exchange rate appreciation affected significantly the inflation rate but also that the monetary response was asymmetric, that is, the decrease of the interest rate was stronger than the increase during 2008. This is particularly interesting when compared with the 2014-2015 period. In fact, as of 2013, the monetary cycle exhibited an easing environment, even with the increasing inflation rate and exchange rate depreciation trend. For example, in 2014, monetary authorities lowered the interest rate from 4.5% to 3.0%, remaining at this level until September 2015. There was a slight increase of 0.5 p.p. at the end of 2015 (see the third shaded area in Figure 7), a policy decision that could be expected to have happened before, given that the inflation rate was above the upper limit since April 2014.

The three episodes highlighted in Figure 7, corresponding to the years analyzed in Table 2, shed light on two features slightly different from the Brazilian case, namely the failures of Chilean monetary authorities embody deflationary processes and there is evidence that the combination of strong exchange rate variation, inflation rate out of the tolerance range and interest rate response seems to occur more clearly during periods of currency appreciation. While the Brazilian case exhibited more periods in which there was the combination of exchange rate depreciation, inflation rate above the upper limit and increasing interest rate, in Chile it seems to occur more frequently the opposite scenario: exchange rate appreciation, inflation rate below the lower limit, and decreasing interest rate.

1.2.3 FX INTERVENTIONS

The Chilean FX market also reflects a greater concern of monetary authorities with respect to exchange rate appreciation, though the interventions have happened modestly. In Figure 8, there are four graphs that aim at emphasizing these characteristics. First, the Foreign Exchange Swap Balance (where positive values represent future dollar sale and negative ones, purchase). Second, Foreign Exchange Net Sale (where positive values represent net dollar sale and negative ones, purchase). Third, Foreign Reserves in dollars. Four, the exchange rate volatility, calculated with a 60 month rolling window (the same statistic shown in the Brazilian case).



Figure 8 – Chilean FX Interventions

Source: Banco Central de Chile (BCCh) and author's calculation.

Over the 2000-2017 period, as occurred in Brazil, Chilean monetary authorities accumulated international reserves, coming from U\$ 14.86 to U\$ 39 billion dollars (see Figure 8). In truth, the increase of international reserves was observed overall until 2014, when they stabilized around U\$ 39 billion dollars. Although this accumulation would, in theory, give more flexibility for Chilean monetary authorities to intervene in the FX market, it will be argued that, in comparison with Brazil and Colombia, interventions were modest. Before the crash of 2008, when the Chilean peso exhibited an appreciation trend, monetary authorities intervened in the market with intention to purchase dollar. From 2005 to 2007, the interventions occurred mostly through swaps, as their stocks remained close to CLP 1000 billion (negative), representing future dollar purchase. Besides to the swaps, a little bit before the crash, there was also dollar purchase made through direct foreign exchange purchase, as can be seen in the second graph of Figure 8. This pattern was reversed only when the consequences of the international crisis hit the Chilean economy (DOOLEY; HUTCHISON, 2009), by reducing the liquidity in dollars in the domestic market. The monetary authorities' strategy changed and both the swaps and the foreign exchange sales operated to provide liquidity to the market.

Nevertheless, the stock of swaps was not as large as it was before the crash. The intervention was made more intensively through net sale, suggesting that the objective was to ensure liquidity for the market. Once the worst consequences of the crisis began to dissipate, the dollar sale policy ended—in fact, Chilean monetary authorities intervened in the FX market, through the instruments shown in Figure 8, with intention to sell dollar only in the aftermath of the Lehman Brothers bankruptcy.

The third period of intervention happened throughout the whole year of 2011, when US\$ 12 billion were purchased by the Banco Central de Chile (BCCh). Despite the fact that the interventions in the FX market were not as pronounced as those of Brazil, for example, it is possible to verify that they were more intense when the exchange rate trend was one of appreciation. The BCCh, for example, purchased much more dollar than sold it through swaps; the same was done through foreign exchange sale/purchase. This suggests, in other words, that from 2000 to 2017 the interventions were made asymmetrically towards appreciation, although the intensity and the frequency of them were not high.

The intervention asymmetry, calculated as the number of monthly intervention that stayed outside the interval of mean plus/minus one standard deviation (i.e., $\mu \pm \sigma$, see Appendix B), indicates that monetary authorities intervened in the FX market asymmetrically towards currency appreciation. With respect to swaps and to foreign exchange sale, the results revealed, respectively, that 82.6% and 69.2% of monthly interventions remained below the lower bound interval. The direction of the asymmetry is different from that of Brazil, where the results indicate that FX interventions occurred more frequently and intensively during periods of currency depreciation.

The volatility of Chilean peso is not very expressive, also when compared with that of Brazil. Whereas in Chile the volatility is around 1.96%, in Brazil, it is 3.57%. This helps to explain why the interventions might be more pronounced in Brazil, given its higher exchange rate volatility, and probably why the exchange rate regime in Chile is often considered to have a higher degree of flexibility. Barajas *et al.* (2014) emphasize that Chile is an exception, given that its central bank does not intervene in the FX market as frequently as the central banks of Brazil, Colombia, and Peru. Similarly, Bermúdez (2014), by analyzing a sample of 7 Latin American countries, concludes that Chile is the exception. The findings of Carrera (2015) are even more appalling as, among 14 Latin American countries, Chile is the only case in which the exchange rate does not exhibit misalignment with its long-run equilibrium.

In short, Chile seems to be the only emerging economy in Latin America to have its monetary policy under IT and to have not intervened significantly in the FX market, but, on the other hand, its exchange rate volatility is not high. The evidence suggests that, although the interventions did not occur systematically, dollar purchase during periods of exchange rate appreciation was stronger than dollar sale during periods of exchange rate depreciation, even considering the measures adopted in the aftermath of the Lehman Brothers bankruptcy, indicating a potential asymmetry towards exchange rate appreciation.

1.2.4 EXCHANGE RATE AND MONETARY AUTHORITIES

The monetary authorities' concern with the exchange rate dynamics is expressed in their main vehicles of communication. Despite the recognition of the exchange rate depreciation impact on domestic prices, the Chilean experience reveals that more attention has been paid to scenarios in which there are strong capital influx and exchange rate appreciation. For example, during the first episode (2003-2004) of inflation rate outside the tolerance range, when the Chilean economy witnessed a deflationary process, monetary authorities emphasized the fact that the peso appreciation was one of the main factors that contributed to their failure.

> Rapid peso appreciation has also significantly and directly affected inflation's behavior, mainly (although not solely) through its impact on domestic fuel prices and automatic indexing clauses affecting regulated fees and fares, such as public transportation and household utilities. Peso appreciation from September to date is calculated to have reduced the 12-month CPI through December by about one percentage point. (BCCH, 2004, p. 13)

This appreciation trend exhibited by the Chilean peso influenced the conduction of monetary policy, given that it pushed down domestic prices considerably.

> Based on this information, in November increasing the interest rate seemed less of an option. Although it was possible to argue that behind peso appreciation were factors that would push activity higher, their impact was expected over a relatively distant horizon, with lower inflation being the direct result of appreciation in the coming quarters. Cutting the interest rate, meanwhile, could be justified by the implications of the month's news---price cuts and trends in the exchange rate on inflation's likely behavior over the next 24 months. The latest projections placed

inflation in the baseline scenario at less than 2% for four quarters, reaching 3% in the fourth quarter of 2005. A cut to the policy rate, therefore, would bring average inflation closer to 3% during the projection horizon. (BCCH, 2004, p. 21)

The peso followed the appreciation trend until almost the end of 2013, but, in 2008, in the aftermath of the Lehman Brothers bankruptcy, there was a sharp currency depreciation (see Figure 6). In this episode, Chilean monetary authorities explained that it was necessary to take several measures in order to ensure liquidity in the market, including direct intervention in the FX market. This was, in truth, the only case in which Chilean monetary authorities intervened considerably in the market, through swaps and Foreign Exchange sales, throughout environments of exchange rate depreciation (see Figure 8).

On September 29, the Central Bank announced the end of the reserve accumulation program along with the supply of liquidity in pesos and dollars through repos and programmed swap operations. On October 10, it announced the expansion of eligible collateral and the extension of one to six months of the dollar swap purchase program. This was complemented by the Ministry of Finance, through the placement of deposits in installments, using resources previously deposited abroad and seasonal surpluses in dollars from the Single Tax Account. [...] Thanks to these measures, and to the fact that tensions in developed markets have eased, the local interbank market is operating normally and the volumes traded exceed those at the beginning of September.¹⁶ (BCCH, 2009, p. 21) (own translation)

If, on the one hand, the interventions of 2008-2009 were justified by the need to provide liquidity for the market, on the other, the interventions during the whole year of 2011, through Foreign Exchange Sales (see Figure 8), tried to some extent to attenuate the pace of the appreciation. Chilean monetary authorities explained that the weakened economic conditions across the developed world and the monetary policy easing in the US had prompted strong capital inflows in EME and currency appreciation, raising the debate about potential measures for restricting their effects.

> [...] the global panorama continued to feature a slow recovery in the advanced economies, with spots of financial turbulence, while the emerging economies continued to grow strongly. Although there were some positive signs for the United States, they were offset by weaker indicators for Europe. The United States began the second phase of quantitative easing, and while the dollar had not depreciated further in international markets

¹⁶"El 29 de septiembre, el Banco Central anunció el término del programa de acumulación de reservas junto con la oferta de liquidez en pesos y dólares a través de operaciones repos y swaps programados. El 10 de octubre, anunció la ampliación de los colaterales elegibles y la extensión de uno a seis meses del programa de compras swap de dólares. Esto fue complementado por el Ministerio de Hacienda, a través de la colocación de depósitos a plazos, utilizando recursos previamente depositados en el exterior y excedentes estacionales en dólares de la Cuenta Única Fiscal. [...] Gracias a estas medidas, y a que las tensiones en los mercados desarrollados se atenuaron, el mercado interbancario local opera con normalidad y los volúmenes transados superan a los de principios de septiembre."

in the last month, there was increasing discussion of the appreciation of local currencies in the emerging economies and possible measures for curbing it. (BCCH, 2010a, p. 21)

The concern with respect to the consequences of capital inflows to the exchange rate was also pointed out by Chilean monetary authorities in the Financial Stability Report of 2010. Despite the benefits, they claimed that attention needed to be paid to the issue due to the loss of competitiveness and financial vulnerabilities that could be created.

> Historically, greater external capital inflows have brought both benefits and costs. On one hand, the greater availability of external capital represents an additional source of financing. On the other, this greater availability of resources can overheat the receiving economy, causing a loss in competitiveness and/or creating financial vulnerabilities. Consequently, the authorities in several countries have expressed concern regarding the challenges that massive capital inflows could raise for monetary policy and financial stability. (BCCH, 2010b, p. 16)

On the other hand, when the peso began to depreciate as of the end of 2013, accumulating a nominal depreciation of 50% at the end of 2015, monetary authorities did not intervene in the FX market in order to curb it or to attenuate its effects on prices. In fact, as argued earlier, even the interest rate was not increased significantly, only 0.5 p.p. at the end of 2015. The fact is that they acknowledged that from 2014 to 2015 the increase observed in inflation was mostly due to the depreciation.

The increase in the annual inflation rate over the past two years has largely been determined by the peso depreciation of approximately 50% relative to the low point in 2013. This is especially evident in annual CPIEFE [*Chilean core inflation*] inflation, which was just under 5% in November. In any case, goods inflation increased the most in recent quarters, due to the direct effect of the higher exchange rate on prices in this subset of the CPI. To a lesser extent, the peso depreciation has also had an impact on CPIEFE services inflation, which remains high. (BCCH, 2015, p. 28)

The exchange rate, in other words, has mostly influenced the decision makingprocess of Chilean monetary authorities, both through interest rate changes and through FX interventions, during episodes of appreciation trend. The justification for this behavior has been based on two arguments. First, the interventions aimed at reducing the effects, most probably the secondary ones, on prices and expectations. Second, monetary authorities exhibited concern regarding the consequences of massive capital inflows for the exchange rate as it could be created misalignment dynamics, loss of competitiveness and financial vulnerability.

1.2.5 MONETARY AUTHORITIES' BEHAVIOR TOWARDS THE EXCHANGE RATE: WHAT THEY SAY AND WHAT THE DATA SAY

Although the inflation level in Chile (the annual inflation average from 2000 to 2017 is 3.6%) has been similar to that of developed economies, its relationship with the exchange rate shares some characteristics observed in EME. The failures of monetary authorities in keeping the inflation rate within the tolerance range have been commonly associated with strong exchange rate variation. Differently from the Brazilian case, though, the periods including intense exchange rate appreciation, detachment of expectations, inflation rate below the lower limit, and monetary policy easing have been more frequent. There were cases in which intense currency depreciation influenced the dynamics of domestic prices (as in 2008 and 2014-2015), but they were not necessarily followed with monetary policy tightening and substantial interventions in the FX market.

Interventions in the FX market have been justified by monetary authorities in light of the attempt to attenuate exchange rate misalignment, loss of competitiveness and financial vulnerability. The data suggested, in fact, that Chilean monetary authorities have been more concerned with loss of competitiveness (i.e., balance of payment issues). Except for the 2008-2009 period, FX interventions have occurred more frequently and intensively during periods of currency appreciation. From 2014 to 2015, for instance, when the Chilean peso depreciated considerably (33% in nominal terms), there was no intervention.

It is worth noting that the Chilean case is different from that of Brazil not only in its direction—towards currency appreciation—but also in its frequency. FX interventions in Chile have been much more modest. So, even though the data suggested that interventions have occurred more frequently and intensively during periods of currency appreciation, with a potential concern with respect to loss of competitiveness, they have not occurred as a systematic policy. In this vein, the Chilean case is less controversial than that of Brazil because monetary authorities have intervened more modestly in the FX market, attenuating the question regarding whether monetary authorities have tried not only to attenuate the propagation of the exchange rate shock but also to influence the exchange rate trajectory itself.

1.3 THE COLOMBIAN EXPERIENCE

1.3.1 EXCHANGE RATE AND INFLATION

The recent monetary experience in Colombia also exhibits the main features of an emerging economy that targets the inflation rate and has an intensive commodity export balance sheet and a relatively free capital market, at least from 2000 to 2017. Similarly to the cases of Brazil and Chile, the exchange rate behavior plays an important role in

explaining the inflation rate, especially during periods of strong currency depreciation. In Figure 9, there are two periods (2007-2008 and 2015-2017) in which the Colombian economy experienced inflation rate outside the tolerance range and significant detachment of expectations from the target, which coincides, except for 2007, with periods of strong exchange rate depreciation¹⁷ (see Figure 10 and Table 3).



Figure 9 – Colombian CPI and Expectations

Source: Banco de la República (Colombia).

Period	Average Annual Inflation	Exchange Rate Variation
2007	5.7%	Appreciation of 10.9%
2008	7.7%	Depreciation of 11.8%
2015-2017	5.5%	Depreciation of 27.6%

Source: Banco de la República (Colombia) and author's calculation.

Until 2007, as can be observed in Figure 9, the inflation rate remained almost all the time within the tolerance range and the expectations did not detach from the target. In truth, a disinflationary process was observed in which expectations were very close to the target, representing the first time in thirty years that Colombian CPI was brought under a single-digit outcome. However, from 2007 to 2008, not only the inflation rate increased beyond the upper limit but also expectations were not well anchored. The explanation for the inflation result of 2007 and 2008 encompasses supply shocks and exchange rate depreciation due to the consequences of the international crisis for EME (DOOLEY; HUTCHISON, 2009).

¹⁷Several factors can help to explain the inflation rate of a given year. The Colombian economy, for example, is very susceptible to supply shocks, due to El Niño and La Niña phenomena, which drastically affect the trajectory of food prices—effects out of central bank's control. Here, however, attention will be paid to the exchange rate effects on the inflation rate.



Figure 10 – CPI x Exchange Rate—Colombia

Source: Banco de la República (Colombia).

The most important determinant of 2007 inflation, according to the BR (2007), was the El Niño phenomenon, severely impacting the food supply and, in turn, considerably elevating the food inflation (8.5%). The particularity of this year comes from the fact that it is the only one in which Colombian economy witnessed, at the same time, inflation target loss mainly caused by supply shock and detachment of expectations. In 2008, when the side-effects of the supply shock were still been materialized into food prices, the exchange rate depreciated 11.8% in nominal terms (see Table 3), intensifying the increase of domestic prices, which ended 2008 with inflation rate of 7.7%. The depreciation magnitude was much lower than those observed in Brazil (31.95%) and Chile (30.05%), but despite that it was still reflected to some extent in the increase of prices.

The influence of the exchange rate on the inflation trajectory can also be perceived during the years that followed the crisis. For example, from 2010 to 2014, while the exchange rate did not exhibit a disruptive behavior, that is, while there was not a sharp and/or intense exchange rate variation, both the inflation rate and the expectations remained close to the target (see Figures 9 and 10). On the other hand, as of late-2014, when the peso began to lose value against the dollar, the scenario was reversed as the inflation rate remained above the upper limit from early-2015 to late-2017 (see Figure 9). One crucial factor that explains the inflation rate over the 2015-2017 period was the currency variation, which accumulated a depreciation of 27.6% in nominal terms.

According to BR (2016), the persistent exchange rate depreciation and the failure to hit the target for several years had an impact on two fundamental variables; first, it affected the expectations due to the failures; second, it affected the degree of indexation in the economy. With respect to the latter, the Board Directors of the Banco de la República explained that because inflation remained above the upper limit during so much time, a vicious circle of indexation between costs and minimum wage was prompted. This economic environment delayed the inflation convergence towards the target and characterized the most unsuccessful period of Colombian IT.

The analysis regarding the exchange rate trajectory in Colombia reveals that the appreciation tendencies and the depreciation tendencies occur in a different manner. Whereas the first one generally occurs during boom times at a slow rate, the second one generally occurs during turbulent times at a more rapid rate, as can be seen, for example, in Figure 10 during the episodes that followed the Lehman Brothers crash (2008) and the end of the Commodity Boom (as of late-2014). Moreover, the Colombian experiences of inflation rate above the upper limit with significant detachment of expectations from the target always happened during periods of strong currency depreciation, with the exception of 2007.

With respect to the exchange rate pass-through, the results of the Colombian case are mixed. Rincón-Castro and Rodríguez-Niño (2016), for instance, find, through a Bayesian VAR approach, that the exchange rate pass-through in Colombia is incomplete, nonlinear and asymmetric. Incomplete means that an exchange rate appreciation/depreciation of α % will represent a variation of less than α % in consumer prices; nonlinear means that the pass-through is more intense during periods of high inflation than those of low inflation; asymmetric means that the pass-through varies depending on the size and sign of the shock. The greater the exchange rate shock, the higher the pass-through. Nevertheless, according to their estimation, a positive exchange rate shock (depreciation) is able to accumulate a pass-through of 11% on CPI, whereas a negative one, 13%, an outcome slightly higher than that of depreciation.

The incompleteness and non-linearity of exchange rate pass-through are results more common in the literature—see, for example, González *et al.* (2010) and Lourenço and Vasconcelos (2018). The asymmetry, however, is not. The findings of González *et al.* (2010) show that the exchange rate pass-through is more intense if the real exchange rate is depreciated and if the nominal exchange rate is depreciating. Lourenço and Vasconcelos (2018), on the other hand, did not find asymmetry, suggesting that currency appreciation/depreciation would have the same impact on consumer prices. The results regarding the asymmetry, therefore, are mixed, given that Rincón-Castro and Rodríguez-Niño (2016) finds asymmetry towards appreciation, González *et al.* (2010) towards depreciation, and Lourenço and Vasconcelos (2018) did not find evidence of asymmetry.

That said, the Colombian evidence suggests that its IT regime has been considerably influenced by exchange rate movements. In particular, episodes of intense depreciation have been associated with target loss and deterioration of expectations, indicating that not only domestic prices can significantly increase due to currency depreciation but also that the exchange rate behavior is of crucial importance for the IT functioning in these EME.

1.3.2 EXCHANGE RATE AND INTEREST RATE

The two episodes in which Colombian monetary authorities faced scenarios with inflation rate above the upper limit and significant detachment of expectations from the target were also characterized by a tightening monetary policy, as one could expect from an IT regime. In Figure 11, the first shaded area highlights the 2007-2008 episode when there was a clear increasing inflation tendency, beyond the tolerance range. As a response, the Board Directors of the Banco de la República increased the interest rate from 7.5% to 10.0%. It is noting, however, that the major interest rate increase (from 7.5% to 9.5%) occurred in 2007 in order to counterbalance the inflationary scenario already in place. This permitted Colombian monetary authorities to respond more timidly during the turbulent year of 2008.



Figure 11 – Colombian Exchange Rate, Interest Rate and CPI Source: Banco de la República (Colombia).

The monetary policy response during the second episode was stronger as the interest rate was raised from 4.5% in 2015 to a local peak of 7.75% in 2016 — representing a rise 3.25% p.p. This, in truth, should be expected under an IT regime, given that not only the inflation rate remained a substantial time above the upper limit but also the expectations detached significantly from the target. The crucial point to understand the particularity of this episode is, once again, the exchange rate. As argued by BR (2016), the intense currency depreciation observed in the period affected the expectations and the degree of indexation in the economy. This reflects, in other words, that part of the interest rate increase was due to the attempt to contain the effects of exchange rate shock, especially on prices and expectations.

Therefore, the Colombian IT regime during periods of inflation rate out of the tolerance range with detachment of expectations from the target is more similar to that of Brazil, at least with respect to two points. First, the exchange rate was generally

suffering from an intense depreciation during these periods. Second, there was also a tightening monetary policy response. The Chilean case, on the other hand, revealed that exchange rate appreciation was also important in the missing of the target and, although during 2014-2015 the Chilean peso also witnessed a significant depreciation (33.0% in nominal terms) with an inflation rate above the upper limit, there was no monetary policy tightening.

1.3.3 FX INTERVENTIONS

The interventions in the FX market in Colombia are mainly made through option trading—i.e., puts (gives the right to sell dollars to the central bank) and call (gives the right to purchase dollars from the central bank). Figure 12 shows central bank net sales, where positive values represent dollar sale and negative ones, dollar purchase. The first remarkable characteristic that can be extracted from this figure is that over the IT period Colombian monetary authorities have intervened in the FX market mostly to purchase dollar, alongside international reserves accumulation (going from U\$ 7.8 to U\$ 47.1 billion dollars throughout the 2000-2017 period).

The episodes in which net sales became positive were very unusual and without a clear pattern. On the other hand, the net purchase presents a relationship with the exchange rate, that is, it lasted as long as the Colombian peso depicted an appreciation tendency. Besides, the international reserves accumulation lasted until late-2014, when (i) the Colombia peso began to depict a depreciation tendency and (ii) monetary authorities almost stopped intervening in the FX market.

The exchange rate, as documented above, evolved as of 2003 towards an appreciation trend, both because the international financial market became more favorable towards EME and because EME experienced a great influx of capitals thanks to the Commodity Boom (REINHART; REINHART; TREBESCH, 2016). Until 2008, despite some periods of positive net sales, the interventions in the FX market were conducted mainly in order to purchase dollar. In early-2007, for example, the BR (2006) recognized that, due to the strong influx of capital, there was a need to massively intervene in the FX market which can be verified in Figure 12 as in March 2007 net sales achieved their lowest level. Interestingly, these interventions could not be justified in light of the exchange rate volatility argument, as until 2007 the Colombian peso exhibited the lowest volatility level (see Figure 12).

A massive intervention in the other direction after the Lehman Brothers bankruptcy, at least at the same magnitude, was not observed, even with the increase of exchange rate volatility. At the end of 2008, the net sale became positive, reflecting the effort of the Banco de la República to ensure dollar liquidity in the market, but in March 2009 it returned to be negative. This intervention, in truth, was very timid, given the turbulence





Source: Banco de la República (Colombia) and author's calculation.

with which financial markets had to deal. While, for example, in March 2007 the net sale reached a negative value of US\$ 1.8 billion, in February 2009 it achieved a positive value of only US\$ 193.5 million.

Once the Colombian peso returned to its appreciation trend, net sales also returned to be negative—a pattern that lasted until late-2014 (see Figure 12), indicating that to some extent monetary authorities were trying to avoid excessive exchange rate appreciation. This becomes even clearer when the FX market is analyzed as of 2014. As the peso begins to depreciate, monetary authorities stop intervening in the FX market; the only exception is May 2016 when net sale became positive (US\$ 255.6 million). Comparing, thus, the periods of exchange rate appreciation and depreciation reveals that Colombian monetary authorities, from 2000 to 2017, were more concerned about currency (over) appreciation.

The intervention asymmetry, as calculated for Brazil and Chile—the number of monthly interventions that stayed outside the interval of the mean plus/minus one standard deviation (i.e., $\mu \pm \sigma$, see Appendix B)—reveals that 62.5% of Colombian interventions remained below the lower bound. Put in another way, from 2000 to 2017, the FX interventions occurred asymmetrically towards currency appreciation.

Bermúdez (2014) also examines the FX market interventions in Colombia and concludes that, during cycles of exchange rate appreciation, monetary authorities seem to respond to appreciation trend rather than to exchange volatility. Likewise, Barajas *et al.*

(2014) document that the interventions not only aim at moderating exchange rate appreciation but also at achieving a given level objective, although not explicitly acknowledged by monetary authorities. The sample of Carrera (2015) also includes Colombia and reveals that its exchange rate exhibits a misalignment towards the long-run equilibrium, and even stronger than that of Brazil.

The justification for intervening in the FX market is usually based on the necessity to diminish exchange rate volatility, but reality seems to indicate that the intention, depending on the circumstances, may go beyond the volatility argument. If, on the one hand, part of the literature has already documented the fact that the interventions occur more frequently than expected, on the other, the reasons behind them are not so evident. Whereas Bermúdez (2014) argues that monetary authorities may seek to avoid excess of volatility and currency appreciation, Barajas *et al.* (2014) and Carrera (2015) enumerate several options, such as limiting pass-through into domestic prices, moderating output costs, avoiding loss of competitiveness and keeping the exchange rate within target zones.

Figure 12 and Appendix B suggest that, similarly to the Brazilian case, Colombian monetary authorities have intervened in the FX market more than expected from a conventional IT regime. However, the reasons behind this behavior seem to be different. Whereas Brazilian monetary authorities have intervened more intensively during periods characterized by currency depreciation and high level of exchange rate volatility, Colombian ones have intervened more intensively during periods of currency appreciation, not necessarily associated with high level of exchange rate volatility, indicating that their concern is more related with loss of competitiveness/balance of payment issues and output costs.

1.3.4 EXCHANGE RATE AND MONETARY AUTHORITIES

Colombian monetary authorities have intervened in the market, more clearly and frequently, through two instruments: interest rate and put/call options (FX interventions). On the one hand, the instruments used are similar to those of Brazilian monetary authorities, but, on the other, the utilization of these instruments may have different purposes in Colombia—not only a different purpose from the Brazilian one but also a different purpose between instruments. It was argued, for the Brazilian experience, that during periods of exchange rate depreciation and increasing volatility, both the monetary tightening and the FX intervention have mainly sought to attenuate the pass-through. For Colombia, it seems that the FX interventions were more related with balance of payments issues, with an avoidance of excessive appreciation (as seen in Figure 12).

At the beginning of the 2000's, when the Colombian peso was exhibiting a strong appreciation tendency, Colombian monetary authorities expressed their concern with the situation, even with the economy evolving satisfactorily in terms of monetary policy as the inflation had gone down from 8.75% in 2000 to 4.48% in 2006. One could argue

that the appreciation would benefit the achievements of monetary authorities and help maintain the inflation rate at a low level. However, the rhetoric of Colombian monetary authorities indicates that they were also paying attention to the effects on competitiveness and productivity.

> The Board of Directors of the Central Bank has expressed its concern about the trend in real peso appreciation, due to the negative impact it could have on production in some tradables sectors and on developments concerning the balance of payments, specifically the current account. A shortfall in the balance of payments might eventually necessitate abrupt changes in the exchange rate to cope with a setback in capital flows to emerging economies. This would have a perverse effect on inflation and productive activity. (BR, 2004, p. 8)

> Considering [...] the extreme likelihood that the 2006 inflation target will be met, the Board of Directors of Banco de la República (BDBR) agreed to leave the interest rate on expansion repos at 6%. This decision was taken at a BDBR meeting on January 27, 2006. Furthermore, based on an assessment of the exchange situation and balance-of-payment projections, the Board of Directors agreed to continue its discretionary intervention in the exchange market. (BR, 2005, p. 8)

It is possible to infer from the Colombian monetary authorities' citation that the intention behind the interest rate manipulation may be different from the intention observed in the FX market. In this case, the FX market intervention pursued to avoid excessive exchange rate appreciation and its perverse effect on competitiveness. This, therefore, shows a different attention paid to the exchange rate from the canonical view of IT regimes (see (TAYLOR, 2000) and (TAYLOR, 2001)) that advocates there should be a response from monetary authorities to exchange rate movements only if their effects threatened the inflation goal. The concern regarding competitiveness, however, seems to have lasted until early-2014, when the Colombian peso began to depict a persistent depreciation tendency and, concomitantly, the interventions in the FX market ceased (see Figure 12).

It could be argued that the interventions in the FX market aimed at avoiding excessive exchange rate appreciation in order to attenuate the pass-through. This does not seem to be a satisfactory explanation. Although the literature exposed above with respect to the asymmetry indicates a mixed result, at the beginning of 2007, a period in which the Colombian peso was appreciating and the FX intervention achieved its strongest level, monetary authorities considered an asymmetric exchange rate pass-through towards depreciation. In this vein, the hypothesis that these interventions occurred to attenuate the pass-through is weak.

As was expected, the pace of these price increases [*CPI for tradables*] declined towards the end of the year, consistent with appreciation as of July. However, the drop in the exchange rate had yet to translate into reductions per se in the PPI or the CPI. This shows the asymmetry that

exists in exchange rate pass-through to prices. With respect to the latter, the evidence for Colombia suggests that prices tied to the exchange rate tend to be far more responsive to increases than to reductions. And, even in times of appreciation, they can increase, although much more slowly. This is particularly true of consumer prices, inasmuch as producer prices have experienced reductions in the past (for example, producer inflation was in negative terrain during 2005).¹⁸ (BR, 2006, p. 35)

Curiously, even assuming that the exchange rate pass-through is asymmetric towards depreciation, during the 2015-2017 episode Colombian monetary authorities did not intervene in the FX market in order to attenuate the pass-through. BR (2016) highlighted that the persistent exchange rate depreciation not only affected the inflation rate but also helped to deteriorate expectations. In fact, the attempt to anchor expectations and to bring the inflation rate back to the tolerance interval was mainly sought through the conventional monetary instrument as the interest rate was increased from 4.5% in 2015 to 7.75% in 2016 (see Figure 11).

The evidence suggests, therefore, that Colombian monetary authorities consider the exchange rate as a key variable in their decision making process, paying attention to its consequences for inflation and for competitiveness. With respect to the former, they seem to avoid the propagation of exchange rate shocks to prices, through interest rate changes. With respect to latter, however, the FX market and the inflation report analysis indicate that they are also concerned about balance of payment issues such as competitiveness and productivity.

1.3.5 MONETARY AUTHORITIES' BEHAVIOR TOWARDS THE EXCHANGE RATE: WHAT THEY SAY AND WHAT THE DATA SAY

Needless to say that, as in Brazil and Chile, the exchange rate have played a crucial role in the functioning of the IT regime in Colombia, as monetary authorities have taken this variable into consideration in their decision making process, either with interventions through the interest rate or with interventions through the FX market. However, the reason why they intervene using each instrument seems to be different; more similar, but not completely so, to the Chilean experience.

Colombian monetary authorities have argued that interventions in the FX market aimed at attenuating balance of payment issues. Although this feature is more similar to the Chilean experience, there have been some differences. First, Colombian monetary authorities have expressed more openly, through inflation reports, their intention to attenuate balance of payment issues. Second, the degree of interventions in Colombia

¹⁸It is worth mentioning that Colombian Inflation Reports of December are generally released in January of the subsequent year—the reason why the Report of December 2006 is discussing measures adopted at the beginning of 2007.

was higher. Chilean monetary authorities, in truth, have intervened modestly in the FX market.

Despite the fact that the Colombian experience is more similar to the Chilean one in terms of potential reasons why monetary authorities have intervened in the FX market, the frequency and intensity of Colombian interventions have been more similar to that of Brazil, but rather than being more comfortable with an appreciated currency, monetary authorities have been more comfortable with a depreciated currency. As in the Brazilian case, the question regarding whether monetary authorities have intervened in the FX market in order to attenuate the propagation of the exchange rate shock or also in order to influence the exchange rate trajectory itself remains up to more analysis.

1.4 SUMMARY

The implementation of IT in Brazil, Colombia, and Chile occurred in the second semester of 1999 and, roughly speaking, this monetary policy option has worked in maintaining inflation under control. In this chapter, the objective was to comprehend the role of the exchange rate for the IT dynamics and for the decision making process of monetary authorities. The analysis revealed that the exchange rate is a key variable to understand the years in which monetary authorities were not able to keep the inflation rate within the tolerance range; a common characteristic in each economy analyzed here.

In Brazil, for example, years of inflation near/above the upper limit witnessed strong currency depreciation, considerable exchange rate pass-through to domestic prices, and persistent detachment of expectations from the target. In Chile, most of the target missing had the exchange rate pass-through, both during currency appreciation and depreciation, among the main factors in explaining the inflation rate. In Colombia, the story is very similar, as scenarios of target missing and deterioration of expectations were associated with intense currency depreciation.

The differences arise when the decision making process is analyzed in light of the exchange rate behavior, that is, how the exchange rate influences monetary authorities' interventions in the market—due to its impact on prices or on other variables such as those with respect to balance of payment issues. Besides, the differences arise in terms of the frequency and intensity of interventions, and their implications, that is, whether monetary authorities have tried to avoid the propagation of the exchange rate shock or also to influence the exchange rate trajectory itself.

Given that the exchange rate have affected the achievements of monetary authorities, it is not puzzling that they consider this variable in their decision making process regarding the interest rate. In Brazil and Colombia, periods of strong exchange rate depreciation and of detachment of expectations from the target have been characterized by monetary policy tightening, reflecting to some extent the attempt to attenuate the propagation of exchange rate shocks into domestic prices. The inverse scenario, however, has been more common in Chile, i.e. periods of strong exchange rate appreciation and of detachment of expectations from the target have been characterized by monetary policy easing.

Interventions in the FX market arose the question whether monetary authorities might pay attention not only to the propagation of the exchange rate shock but also to the exchange rate trajectory itself. The experiences of Colombia and Chile suggested that interventions have been related to balance of payment issues, such as competitiveness, productivity, and output costs. In Table 4, it is possible to see that, despite the differences with regard to the average exchange rate volatility and the degree of FX intervention¹⁹, both Colombia and Chile had an FX intervention asymmetry²⁰ towards appreciation.

	Brazil	Chile	Colombia
Average Annual Inflation	6.5%	3.3%	5.1%
Average Exchange Rate Volatility	3.57%	1.96%	2.25%
Degree of FX Intervention	High	Low	High
Intervention Asymmetry	Depreciation	Appreciation	Appreciation

Table 4 – Summary

Brazilian monetary authorities have also intervened in the FX market, with a high degree, but the intervention asymmetry is towards depreciation. The explanation commonly given by monetary authorities for this behavior is based on the attempt to diminish exchange rate volatility and its impact on prices—which seems to be fair as the Brazilian currency presented the highest average exchange rate volatility (3.57% in Brazil, while 1.96% in Chile and 2.25% in Colombia)—, but due to the fact that interventions have been frequent and intense, especially during periods of intense exchange rate pass-through, the question regarding whether monetary authorities have also tried to influence the exchange rate trajectory and to attenuate its pass-through into price is not completely unraveled.

The importance of the exchange rate for these economies, therefore, revealed that monetary authorities may intervene in the market through two instruments, but not necessarily with the same purpose. In Brazil, on the one hand, the evidence suggested that interventions both through the interest rate and through the FX market have been based on the inflation rate goal—the behavior of the exchange rate has been taken into consideration due to its potential impact on prices and expectations; the question is whether interventions aimed also at influencing the exchange rate trajectory itself. In

¹⁹This classification is based on the frequency of FX intervention made by monetary authorities in each country, see Figures 7, 8, and 9, and, as discussed in the chapter, in line with the literature (e.g. (BARAJAS *et al.*, 2014), (BERMÚDEZ, 2014), (CÉSPEDES; CHANG; VELASCO, 2014), and (CHANG, 2008)).

²⁰This classification, as discussed in the chapter, was made according to the Appendix B.

Chile and Colombia, on the other, FX market interventions have been made in order to attenuate the exchange rate effects on the balance of payments. The Chilean case, in fact, was less controversial, as monetary authorities have intervened more modestly in the FX market, but the Colombian case also shed light on the question whether interventions aimed at influencing the exchange rate trajectory itself.

The literature has to some extent investigated the role of the exchange rate in Latin American IT regimes. Barajas *et al.* (2014), for example, claim that although IT adoption presupposes a move towards greater exchange rate flexibility, the evidence indicates that this move was weaker than expected as monetary authorities have counteracted exchange rate movements—not only avoiding the propagation of the exchange rate shock—to limit pass-through into domestic prices, output costs, loss of competitiveness, or adverse balance sheet effects. In line with the findings exposed above, the authors argue that, except for Brazil, the "fear of appreciation" is greater than the "fear of depreciation". González (2017) argues that during the recent commodity boom (2003-2013) Latin American economies had a "fear of appreciation", as they avoided currency appreciation due to its effects on the balance of payments. The evidence shown here suggested, however, that this thesis might not be applicable to all Latin American economies—the Brazilian case revealed that monetary authorities have been more concerned about currency depreciation.

Bermúdez (2014) also emphasizes that Brazil and Colombia have intensively intervened in the FX market, seeking to avoid not only exchange rate volatility but also to avoid appreciation/depreciation trends. Céspedes, Chang and Velasco (2014) argue that, in truth, central banks in Latin America have pursued two distinctive objectives, namely the control of the inflation rate through the interest rate, and of the exchange rate, through FX market interventions. Given this specific argument regarding the IT regime in Latin America, Céspedes, Chang and Velasco (2017) made an effort to model a monetary policy framework in which there are two objectives (inflation target and exchange rate) and two instruments (interest rate and FX interventions). They analyze the effect, for example, of monetary authorities having an inflation target and operating through sterilized foreign exchange. Their model reveals that FX interventions matter and can bring beneficial effects for monetary policy—whenever financial constraints are tightened. They conclude, however, that the model does not provide a rationale for the pattern of FX interventions observed in Latin America as monetary authorities have used sterilized foreign exchange even during non-crisis periods.

Likewise, by deriving a model in which monetary authorities have two targets—the inflation rate and exchange rate disequilibrium—and two instruments—the interest rate and FX interventions—, Ghosh, Ostry and Chamon (2016) show not only the consistency of this regime but also the improvement of economic welfare. In fact, in case of volatile exchange rate the best policy will be to intervene in the FX market in order to stabilize

disequilibria.

Even discarding the thesis that central banks have a target with respect to the exchange rate, findings shown here differed from the literature to the point that it has shown a variety of IT regimes in Latin America, in which interventions in the FX market have been asymmetrical, but not in the same direction for each economy, and not with the same intensity and frequency. The main differences among the IT regimes analyzed here were in two aspects. First, the potential reasons for the importance of the exchange rate; whereas in Brazil this variable seems to have a crucial importance due to its effects on prices, in Chile and Colombia, the importance seems also to be related to its effects on competitiveness/balance of payment issues. Second, the degree of FX interventions; whereas in Chile interventions have been modest, in Brazil and Colombia, although not in the same direction, interventions have been intense and frequent, suggesting that there was a possibility that monetary authorities have tried to some extent to influence the exchange rate trajectory.

Of course that the aim to keep the inflation rate low and stable remains a common characteristic among these economies, but the point is that the use of instruments varies in terms of intensity and purpose—whereas monetary authorities in Brazil seems to be intensively focused on inflation goals, in Chile and Colombia, they seem also to pay attention to balance of payment issues; whereas Brazilian and Colombian monetary authorities have intervened considerably in the FX market, Chilean ones have not.

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2 ECONOMETRIC EXERCISE

The discussion concerning monetary policy in Latin America made in Chapter 1 sheds light on the particular role of exchange rate movements in the context of EME under Inflation Targeting (IT). Not only inflation dynamics has been affected by the exchange rate but also the decision-making process of monetary authorities—as discussed in Chapter 1. The exchange rate pass-through intensity has varied over time, and among countries (Brazil, Colombia, and Chile), but a sharing characteristic is that this phenomenon is not negligible nor small inasmuch as it has considerably influenced the attainments/failures of central banks with respect to their inflation targets. One may ask, for instance, whether exchange rate changes, given their consequences for prices and expectations, affect the short-term interest rate dynamics. The aim of Chapter 2 is to investigate this issue by estimating Monetary Reaction Functions (MRF) including different measures of exchange rate changes and asymmetries¹.

The central bank action in order to attenuate currency appreciation/depreciation and exchange rate volatility can be done through different ways: reserve auction/accumulation, swap sales, and interest rate changes, for example. MPF specifically allows to verify how central banks react to exchange rate changes through the short-term interest rate, that is, through the Monetary Policy Rate (MPR) generally used in IT regimes as the main instrument. The exercise proposed here, applied to Brazil, Colombia, and Chile, also evaluates whether monetary authorities react asymmetrically with regard to exchange rate changes, i.e., currency appreciation/depreciation. Chapter 2 is divided into two sections: Estimation Procedure, explaining the methodology and the data used in the exercise; and Results, exposing the interpretation of the Granger-Causality test and of the estimated MRF.

2.1 ESTIMATION PROCEDURE

The econometric exercise aims at estimating three equations. First, in order to examine whether exchange rate changes matter to explain the decision-making process of monetary authorities with respect to the short-term interest rate, equation 2.1 is estimated. Second, beyond the fact that monetary authorities might take into consideration the exchange rate to intervene in the market through the interest rate, they can act asymmetrically towards currency appreciation/depreciation. For this purpose, the equation

¹Monetary Reaction Functions here aim at incorporating a potential asymmetry of monetary authorities' response towards exchange rate changes, that is, whether interest rate changes are more sensitive towards currency appreciation or towards currency depreciation.

2.2 is estimated. Third, as a robustness check exercise towards the exchange rate asymmetry, where the appreciation/depreciation is only considered from a threshold of 2%, equation 2.3 is estimated.

$$i_{t} = \alpha_{0} + \alpha_{1}i_{t-1} + \alpha_{2}(E_{t}\pi_{t+11} - \pi_{t}^{*}) + \alpha_{3}y_{t}^{g} + \alpha_{4}\Delta q_{t} + \alpha_{5}\Delta q_{t-1}$$
(2.1)

Where i_t is the monetary policy rate (generally the short-term interest rate), $E_t \pi_{t+11}$ is the expected inflation over the next 12 months (including the current month), π_t^* is the annual inflation target, y_t^g is the output gap, q_t is the exchange rate.

$$i_t = \beta_0 + \beta_1 i_{t-1} + \beta_2 (E_t \pi_{t+11} - \pi_t^*) + \beta_3 y_t^g + \beta_4 x_t^+ + \beta_5 x_t^-$$
(2.2)

Where $x_t^+ = max(0, \Delta q_t)$ and $x_t^- = min(0, \Delta q_t)$. It is of interest to note that x_t^+ represents the depreciation variable and x_t^- the appreciation variable. They can reveal whether central banks in Latin America are not only concerned with exchange rate movements, but also with their direction and magnitude.

$$i_t = \gamma_0 + \gamma_1 i_{t-1} + \gamma_2 (E_t \pi_{t+11} - \pi_t^*) + \gamma_3 y_t^g + \gamma_4 z_t^+ + \gamma_5 z_t^-$$
(2.3)

Where

$$z_t^+ = \begin{cases} \Delta q_t, if \Delta q_t > 0.02 \cdot q_{t-1} \\ 0, otherwise \end{cases}$$
$$z_t^- = \begin{cases} \Delta q_t, if \Delta q_t < -0.02 \cdot q_{t-1} \\ 0, otherwise \end{cases}$$

The variables z_t^+ and z_t^- also represent the depreciation and appreciation variables, respectively. However, behind them there is the assumption that monetary authorities might not respond to small exchange rate deviations, only if it is bigger than 2% of the previous exchange rate.

In truth, this exercise, including the estimation of equations 2.1, 2.2, and 2.3, was first applied to Turkey by Benlialper and Cömert (2015) with intention to verify a potential asymmetrical behavior from monetary authorities towards exchange rate changes. The authors use the same asymmetrical variables and thresholds. The difference is the estimation procedure as Benlialper and Cömert (2015) estimate VAR models and Impulse-Response Functions. Here, equations will be estimated through a GMM (Generalized Method of Moments) procedure, with a robustness of the covariance matrix to heteroskedasticity and serial autocorrelation in the residuals, applying the method of Newey and West (1987) with Bartlett kernel and fixed bandwidth. The instruments are 5 lagged values of the short-term interest rate, the output gap and the CPI, being careful to not have a problem of overspecification, which is verified through the J test. The necessity of predetermined and strong instruments to run a GMM makes the explanatory variables natural candidates.

The GMM procedure has become a widespread technique to estimate monetary reaction functions, regardless their specific format (i.e., they may include or not exchange rate changes, nonlinearities, asymmetries, etc.). See, for instance, Gerdesmeier and Roffia (2003), Mohanty and Klau (2005), Aizenman, Hutchison and Noy (2011), and Medeiros, Portugal and Aragón (2016). Besides that, estimating equations 2.1, 2.2, and 2.3 through a GMM procedure makes the comparison with the Latin American literature easier, especially with results presented by Mohanty and Klau (2005).

It is of interest to note that, because the role played by the exchange rate in the context of IT in Latin America is the main objective of study in this dissertation, one may ask whether it exists a reverse causality or even a simultaneous causality between the exchange rate and the interest rate, that is, if not only the exchange rate movement helps in the prediction of the interest rate but also if the latter helps in the prediction of the former. For this reason, a Granger-Causality test is run with intention to verify which direction holds (if any).

The literature focused on estimating MRFs (e.g. Gerdesmeier and Roffia (2003), Mohanty and Klau (2005), Aizenman, Hutchison and Noy (2011), and Medeiros, Portugal and Aragón (2016)) does not present exercises with intention to verify somehow the existence of reverse causality. In this vein, a Granger-Causality test can complement and can help understand not only results already existent in the literature but also results presented here.

2.1.1 THE DATA

This subsection details the data with which the research and the econometric exercise have to deal. Bellow, there is a description for each variable and proxy collected and used, but, before going through it, let's clarify the way in which the proxy variable were estimated, namely (i) the output gap and (ii) the inflation gap, which requires a measure of inflation expectation.

The HP filter has been largely used as a technique to decompose a nonstationary variable into trend and cycle (stationary variable). In the context of MRF, the output gap needs to be estimated, representing the component of the economic activity cycle, and a substantial part of the literature has estimated it through the HP filter (e.g. Mohanty and Klau (2005), Benlialper and Cömert (2015), Barajas *et al.* (2014)). Even economists who use more than one technique maintain the HP filter as a standard approach (e.g.

Gerdesmeier and Roffia (2003) and Medeiros, Portugal and Aragón (2016)). Accordingly, the results exposed here have applied this filter in order to estimate the output gap. It is worth noting that, in Appendix C, it can be found the estimated equations with the filter suggested by Hamilton (2017); results with the HP filter are highlighted because the comparison with the literature is easier to be make and because some estimated Brazilian parameters with respect to the asymmetric variables are of hard interpretation, using the Hamilton filter.

The inflation targeting framework has the goal, among others, to anchor the inflation expectation in the medium-term horizon. From this perspective, the inflation gap needs to take into consideration the expected inflation of economic agents, but the question is at which horizon the central bank is looking. With the intention to consider this particular characteristic, the expected inflation gap, represented by $(E_t \pi_{t+11} - \pi_t^*)$ is calculated with the expected inflation over the next 12 months (including the current month).

Finally, the equations were estimated with monthly data from 2003 to 2017. The decision about the start date was made based on data availability and taking into account the fact that it is necessary some time to consolidate a monetary policy framework.² In this vein, the Brazilian estimation begins in 2003 due to their data availability of output gap (estimated with IBC-Br), but note that this unwittingly excludes the IT beginning. The estimation of Colombian and Chilean equations begins in 2003 in order to exclude the IT beginning.

2.1.1.1 Data Description

Brazil: (1) Monetary policy rate: Selic—short-term interest rate; (2) Inflation: IPCA (Brazilian CPI) and the inflation expectation disclosed by the central bank; (3) Activity index to estimate the output gap: IBC-Br (Índice de Atividade Econômica do Banco Central do Brasil); (4) Exchange rate: nominal rate at the end of the month. All series were downloaded from Banco Central do Brasil.

Colombia: (1) Monetary policy rate: short-term repo rate, also known as the benchmark intervention rate from Banco de la Repúplica (Colombia); (2) Inflation: Colombian CPI and the inflation expectation disclosed by the central bank; (3) Activity index to estimate the output gap: IPI (Índice de Producción Industrial); (4) Exchange rate: nominal rate at the end of the month. All series were downloaded from Banco de la Repúplica (Colombia).

Chile: (1) Monetary policy rate: short-term repo rate, also known as the benchmark intervention rate from Banco Central de Chile; (2) Inflation: Chilean CPI and the inflation

 $^{^2\}mathrm{Brazil},$ Chile, and Colombia adopted IT as their monetary policy framework in the second semester of 1999.

expectation disclosed by the central bank; (3) Activity index to estimate the output gap: IMACEC (Indicador Mensual de Actividad Económica); (4) Exchange rate: nominal rate at the end of the month. All series were downloaded from Banco Central de Chile.

2.2 RESULTS

Results are separated into two subsections: Granger-Causality and Monetary Reaction Functions (MRF). In the first one, Results regarding the G-C test between the exchange rate and the interest rate are shown, done for Brazil, Colombia, and Chile. In the second, the estimated reaction functions for the same economies are presented, including the equations without and with asymmetry. The first exercise, although simple, gives some insights with regard to the relationship between these variables by suggesting a potential temporal ordering, whereas the second reflects the decision-making process with regard to the short-term interest rate.

2.2.1 GRANGER CAUSALITY

Causality has been an interest of economists for a long time as, once understood the correct direction, it helps to formulate theory—and maybe synthesize it into equations—about two or more economic variables. However, it may occur that two variables impact each other at the same time—the so-called simultaneous causality. There are several examples of this problem in the literature: aggregate consumption and national income, salary and effort, levels of crime and number of police officers, etc.

Here, within the context of monetary economics, one may ask if the exchange rate and the interest rate do not share a simultaneous causation, which would bring an econometric issue by estimating equations where the former is considered exogenous and the latter endogenous. In order to clarify this potential question, and because the econometric exercise is dealing with time series, a classical G-C test, first proposed by Granger (1969), is applied to these variables. Besides, this test is another way of analyzing the relationship between the interest rate and the exchange rate in the sense that identifies each one (or maybe both) helps with its past values to predict the other variable - concept of causal ordering. Finally, it is important to say that this exercise only aims to comprehend the temporal ordering of the variables in question and its implication, not being a goal to determine if there is a causality in any direction as understood in the classical econometrics literature.

A particularity of this econometric exercise is that the variables submitted to the test need to be covariance stationary. To check whether they are stationary, two unit root tests are used, namely: ADF (Augmented Dickey-Fuller) suggested by Dickey and Fuller (1981), and PP test suggested by Phillips and Perron (1988). The determination of

lags to estimate the equation to run the ADF tests was based on the Akaike Information Criterion (AIC), while the PP tests, a semi-parametric alternative, were applied with Bartlett kernel spectral estimation and Newey-West bandwidth. The exogenous regressors, i.e. the constant c and the linear trend t, were included in equations when statistically significant.

	Interest rate		Ex	Exchange rate		
	\mathbf{ER}	ADF	PP	\mathbf{ER}	ADF	\mathbf{PP}
Brazil	c,t	-6.46***	-3.27*	-	0.33	-1.77
Colombia	с	-2.96^{**}	-2.35	-	0.59	0.61
Chile	с	-3.73***	-3.13**	с	-2.16	-2.01

Table 5 – Unit root tests

***Significance at 1% **Significance at 5%

*Significance at 10%

ER: Exogenous Regressors

Table 5 shows the unit root test results. With respect to the interest rate, the general conclusion is that this variable is covariance stationary for each country of the sample. The only case in which the result seems to be dubious is that of Colombia, as through the ADF test the null hypothesis of unit root is rejected but through the PP test this hypothesis is not rejected, even if considered at the significance level of 10%. For this reason, the G-C test for Colombian variables, shown in Table 6, was run with the the first difference of interest rate.³ The results regarding the exchange rate indicate that this variable is not covariance stationary, so the first difference is used to run the G-C test.

Table 6 – Granger Causality Test

Null Hypothesis	Brazil	Colombia	Chile
Exchange rate does not G-C interest rate (p-value)	0.0013	0.9118	0.0027
Interest rate does not G-C exchange rate (<i>p</i> -value)	0.8492	0.8200	0.1737

The lag length used to run the Granger Causality test (7 for Brazil, 2 for Colombia, and 2 for Chile) was decided according to information criteria by estimating a VAR model.

In Table 6, the G-C test results are shown for Brazil, Colombia, and Chile. Except for Colombia, whose test does not reflect that exists a G-C in any direction, there is evidence that the exchange rate helps predict the interest rate, but the inverse causation is not true - note that the null hypotheses that the exchange rate does not G-C the interest rate are rejected at the significance level of 1%, but the null hypotheses that the interest rate does not G-C the exchange rate are not rejected, even if considered at the significance level of 10%. But, in the context of Inflation Targeting in Latin America, what is the implication of these results?

³As the unit root tests for the Colombian interest rate was dubious, the G-C test was also applied with the interest rate level, but the results have not changed in any direction.

Of course, the direct implication is that exchange rate changes, except for the Colombian case, comes temporally before interest rate changes (causal ordering), but this might also suggest that the exchange rate is a variable of importance in the decision-making process of central banks in Latin America whose objective is to achieve the announced inflation target. The G-C test alone is not capable of bringing this conclusion nor is it capable of explaining why this scenario exists, although it can be a powerful exercise to enhance the understanding about the theme, since the interest rate, often called the monetary policy rate (MPR), is the main instrument of monetary authorities. For this reason, the next subsection explores the relationship between the interest rate and the exchange rate more accurately with MRF.

2.2.2 MONETARY REACTION FUNCTION (MRF)

The study of Monetary Reaction Function (MRF) has become a relevant part of monetary economics literature after the publication of (TAYLOR, 1993)'s paper, through which he claims that a good specification, in the U.S. case, should have the inflation rate and real income changes as arguments, albeit the problems of econometric evaluations which arise with them representing the decision-making process of central banks. The main consequence of his ideas was a dissemination of researches with intention to understand the concept behind the equation and to estimate it for different central banks, under different specifications. For instance, Mohanty and Klau (2005) have estimated the MRF for thirteen EME, including in the equation not only the inflation and output gaps but also exchange rate changes; Gerdesmeier and Roffia (2003) have done the same, with more than three specifications, including different variables, but for the euro area; Medeiros, Portugal and Aragón (2016) have analyzed non-linearities for the Brazilian case.

If, on the one hand, (TAYLOR, 1993; TAYLOR, 2000; TAYLOR, 2001) recognizes that monetary authorities, even outside of the U.S., should not mechanically follow a MRF as the real world is much more complicated than an equation is capable of drafting, on the other, he points out that a simple rule, including the inflation rate and the output gap, is representative in describing the central bank behavior in terms of intervention through the monetary policy rate. To put it in simple terms, Taylor argues that monetary authorities should not publicly compromise themselves to a specific rule, which would diminish their degrees of liberty in policy-making, but this does not imply that an equation is not a good way to describe how the monetary policy rate generally changes. His standpoint, in other words, is that a hypothetical and simple rule might work with its general features in guiding the decisions made by policymakers.

The literature interchange the terms "Monetary Policy Rule" and "Monetary Reaction Function" as synonyms. The first one, however, is too strict and implies the idea of a rule that must be followed by monetary authorities. The reality is much more cumbersome than equations can embody and, for this reason, the second term seems to be more appropriate. Also, there is no central bank that releases a formal equation by which monetary policy is strictly conducted. The MRF expression will, therefore, be adopted here as it refers to a non-observable equation and reflects how monetary authorities react to changes in some explanatory variables.

It is not unreal to suppose, or even implausible, that monetary authorities also take into consideration, in addition to the output and inflation gaps, other explanatory variables (e.g. exchange rate, commodity prices, money growth, stock market index, etc.) or to suppose that there are non-linearities/asymmetries in the MRF. This point is particularly important when it comes to the role of the exchange rate in monetary regimes under IT. Taylor (2001) emphasizes that, if the monetary regime is not under exchange rate targets, the only remaining effective monetary policy is one based on a tripod: (i) flexible exchange rate; (ii) inflation target; and (iii) monetary policy rule. As a result, the exchange rate should freely float and there would be no reason to monetary authorities to react to its movements.

The evidence of Latin American economies has drawn the exchange rate into a different regime in which some effort has been put to contain exchange rate pressures—via interest rate changes and/or FX interventions. Calvo and Reinhart (2002) argue that there is a "fear of floating" in EME, especially because they generally have a higher level of pass-through from exchange rate changes to prices, making their policymakers more concerned about the variability of their currencies, since a sharp appreciation/depreciation can jeopardize the goal of achieving the inflation target. Modenesi, Luporini and Pimentel (2017), for instance, show, through a SVAR estimation, that there is an asymmetric pass-through from exchange rate changes to prices in Brazil, in which currency devaluation effects are stronger than those of appreciation. Accordingly, Lourenço and Vasconcelos (2018) estimated, through an Error Correction Model (ECM) including exchange rate asymmetries, that the pass-through in Brazil is stronger when currency depreciates, but, interestingly, stronger when currency appreciates in the Chilean case. No evidence of asymmetry was found for the pass-through in Colombia.

That being said, the exchange rate seems to be a variable of importance in EME and its effects on the capacity of monetary authorities to achieve the inflation target cannot be ignored (it has been argued in Chapter 1 that, throughout periods of intense currency appreciation/depreciation, monetary authorities struggled to keep the inflation rate within the tolerance range). For this reason, the central objective in this chapter is to estimate MRFs for Brazil, Colombian, and Chile, including the exchange rate, with and without asymmetry, among the explanatory variables. The results are separated into Tables 7 (equation 2.1), 8 (equation 2.2), and 9 (equation 2.3).

Table 7 shows the estimated equations without asymmetry for Brazil, Colombia,
Parameters	Brazil	Colombia	Chile
α_0	-0.94*	0.77***	0.18**
	(1.92)	(3.76)	(2.02)
α_1	1.05^{***}	0.89^{***}	0.96^{***}
	(31.67)	(30.84)	(44.86)
$lpha_2$	0.28^{***}	0.03	0.31^{***}
	(2.85)	(0.51)	(3.1)
$lpha_3$	0.08^{***}	0.08^{***}	0.05
	(2.96)	(8.19)	(1.22)
$lpha_4$	-1.01	0.005^{***}	0.01^{*}
	(-0.41)	(5.23)	(1.81)
$lpha_5$	3.34^{**}	-0.0002	-0.001
	(2.24)	(-0.24)	(-0.2)
J-statistic (p-value)	0.58	0.98	0.4
R^2	0.97	0.94	0.96

Table 7 – Model without Asymmetry—Equation 2.1

*** Significance at 1%

** Significance at 5%

* Significance at 10%

 $t\text{-}statistics \ in \ brackets$

Parameters	Brazil	Colombia	Chile
β_0	-1.06	0.70***	0.35***
	(-1.33)	(4.07)	(3.16)
β_1	0.97^{***}	0.90^{***}	0.93^{***}
	(25.41)	(33.38)	(48.6)
eta_2	0.33^{***}	0.08	0.36^{***}
	(2.82)	(1.21)	(4.51)
eta_3	0.11^{**}	0.07^{***}	0.07^{*}
	(2.28)	(8.12)	(1.94)
eta_4	13.08*	0.002^{**}	0.003
	(1.83)	(2.00)	(0.34)
eta_5	-5.40	0.006^{***}	0.02^{**}
	(-1.38)	(3.85)	(2.59)
J-statistic (p-value)	0.74	0.79	0.36
R^2	0.92	0.95	0.97

Table 8 – Model with Asymmetry—Equation 2.2

*** Significance at 1%

** Significance at 5%

* Significance at 10%

 $t\text{-}statistics \ in \ brackets$

and Chile. The Brazilian reaction function suggests that the central bank also responds to exchange rate changes, aside from the traditional variables (lagged interest rate, output gap, and inflation gap). The interesting finding is that the parameter (α_4) with regard to Δq_t is not statistically significant (Brazilian equation in Table 7), but the parameter (α_5)

parameters	Brazil	Colombia	Chile
γ_0	-0.55	1.1^{***}	0.25***
	(-0.83)	(4.56)	(2.68)
γ_1	0.96^{***}	0.82^{***}	0.95^{***}
	(24.06)	(22.05)	(51.09)
γ_2	0.23**	0.18^{*}	0.28^{***}
	(2.03)	(1.8)	(3.22)
γ_3	0.07	0.08^{***}	0.05
	(1.6)	(5.58)	(1.54)
γ_4	14.16^{***}	0.005^{***}	0.007
	(3.11)	(2.94)	(0.68)
γ_5	0.86	0.006^{***}	0.02^{***}
	(0.32)	(3.57)	(2.95)
J-statistic (p-value)	0.58	0.73	0.39
R^2	0.90	0.91	0.96
*** Significance at 1%			

Table 9 – Models with Asymmetry—Equation 2.3

*** Significance at 1%

** Significance at 5%

* Significance at 10%

t-statistics in brackets

with regard to Δq_{t-1} is significant. This result is similar to that of Mohanty and Klau (2005), who found a significant parameter for the lagged exchange rate change but not for the contemporaneous change.

All Brazilian parameters have an acceptable sign in terms of economic theory, except for α_0 , which was negative and significant at 10%. This parameter, in theory, represents the sum of the potential output and the inflation target (i.e., $\alpha_0 = \pi_t^* + y_t^*$), or the natural interest rate. In econometric terms, however, it captures to some extent non-observable constant elements from the error term. The negative sign may be due to some Brazilian characteristic not incorporated into the model. It is worth noting that, for equations 2.2 and 2.3, α_0 remains with negative sign but not statistically significant.

In line with Brazilian results, Colombian and Chilean equations shown in Table 7 also suggest that the exchange rate helps explain interest rate changes as they have the parameter α_4 with respect to the variable Δq_t statistically significant.⁴ The difference relies on parameters α_2 with respect to $(E_t \pi_{t+11} - \pi_t^*)$ and α_3 with respect to y_t^g . While the former is not significant for Colombian equation, the latter is not for Chilean equation. This result does not change considerably in equations with asymmetry (Tables 8 and 9).

The Chilean result is particularly different from that of Mohanty and Klau (2005).

⁴Note that, differently from Brazil, the estimated parameters of exchange rate changes seem to be too small (about to 0.005 and 0.01 for Colombia and Chile, respectively). However, recall that the Colombian exchange rate is more than 2000 for 1 dollar and the Chilean, more than 500 for 1 dollar. Since the parameter represents, ceteris paribus, the impact of exchange rate change of 1 on interest rate, the magnitude of the estimated parameters is economically understandable.

First, these authors have found a significant parameter with respect to y_t^g . Second, both parameters with respect to exchange rate changes (i.e., lagged and contemporaneous) were significant, but with inverted signs—offsetting each other—suggesting that exchange rate changes are not taken into consideration in the conduction of monetary policy. Mohanty and Klau (2005) have not included Colombia in their study.

When it comes to the econometric exercise including the variables representing the asymmetry—equations that were not estimated for Latin American economies before—, the results vary for each country. In Table 8, the equations reveal that the interest rate responds asymmetrically towards currency depreciation in Brazil, but towards appreciation in Chile, and no asymmetry in Colombia—which can be observed through the significance of parameters β_4 with respect to $x_t^+ = max(0, \Delta q_t)$ and β_5 with respect to $x_t^- = min(0, \Delta q_t)$. Accordingly, the equations shown in Table 9, where the appreciation/depreciation is considered only from a threshold of 2%, suggest the same asymmetric behavior for Brazil, Colombia, and Chile. Lourenço and Vasconcelos (2018) estimated the exchange rate pass-through for these economies and found evidence in the same direction, that is, an asymmetric pass-through towards currency depreciation in Brazil, towards appreciation in Chile, but no evidence of asymmetry in Colombia. The magnitude and the direction of pass-through, therefore, seems to be helpful in explaining why monetary authorities might asymmetrically behave towards exchange rate movements.

The monetary decision-making process in these economies, in other words, suggests that the exchange rate behavior is one of the variables that can help predict the short-term interest rate trajectory. Say, for example, that the Brazilian economy is going through a nominal exchange rate depreciation, considered by economic agents as persistent and capable of bringing inflationary pressures beyond the expected. Results found here, through the G-C test and the MRF, indicate that, ceteris paribus, monetary authorities might raise the interest rate. This does not necessarily imply that monetary authorities try to control the exchange rate via interest rate movements, as argued by Benlialper and Cömert (2015) with the IT analysis in Turkey. The MRF tell us that, in the conduction of monetary policy in EME under IT, exchange rate changes are taken into consideration and can explain, to some extent, the variations of interest rate.

The reasons behind this fact has to do, at least to some extent, with some characteristics of EME. The exchange rate pass-through plays a pivotal role in explaining this scenario as many times, during strong currency variation, the inflation target was missed. The effects of the Commodity Boom's end is a good example of it, since currencies of several EME were losing value against the dollar and the result was a considerable pass-through from exchange rate changes to prices, which jeopardize the monetary goal in Brazil, Colombia, and Chile. Another relevant point is the pro-cyclical capital flow dynamics that during periods of economic stability tends to attract hot money and, in turn, to appreciate the exchange rate, but during periods of turbulence tends to experience sharp capital flows and to depreciate the exchange rate. Put it another way, the exchange rate absorb different shocks, representing the capital flow vulnerability of EME, and its movements can affect the ability of monetary authorities in achieving the inflation target.

Results presented here differ from the previous literature (e.g. Gerdesmeier and Roffia (2003), Mohanty and Klau (2005), Aizenman, Hutchison and Noy (2011), and Medeiros, Portugal and Aragón (2016)) focused on estimating MRFs by incorporating asymmetries in the response of monetary authorities, through interest rate changes, to exchange rate changes. Benlialper and Cömert (2015) applied a similar exercise for Turkey, finding an asymmetric response of monetary authorities towards currency depreciation, but for Latin America this exercise had not been done yet. So, the literature had already documented that monetary authorities in Latin America responded, through interest rate changes, to exchange rate changes. The contribution exposed here suggested that the response might be asymmetrical, towards depreciation in Brazil, and towards appreciation in Chile.

The nexus between Chapter 1 and 2 also highlights the fact that asymmetries of monetary authorities' response through interest rate changes and through FX market interventions seem to go in the same direction. In Brazil, for instance, monetary authorities seem to respond asymmetrically towards currency depreciation, with both instruments. In Chile, on the other hand, the response seem to be asymmetrical towards currency appreciation, also with both instruments. In Colombia, although an asymmetrical response towards currency appreciation was found in the FX market, MRFs have not indicated an asymmetrical response towards exchange rate changes.

In addition to results found with MRFs, Granger-Causality tests suggested that, in Brazil and Chile, interest rate changes help predict exchange rate changes, but the inverse causation did not hold. For the Colombian case, G-C tests did not hold in any direction. Put it another way, interest rate changes, ceteris paribus, comes after exchange rate changes. This reflects that if monetary authorities try to influence the exchange rate trajectory through interest rate changes, the effectiveness of this action is limited—if they try to do so, it is likely to be done through FX interventions.

To sum up, results of Chapter 1 and 2 suggest that, despite the similarities of Brazil, Chile, and Colombia, there is a variety of IT regimes. In Brazil, monetary authorities seem to respond asymmetrically towards currency depreciation, both through interest rate changes and through FX interventions. In Chile, although FX interventions occurred modestly, monetary authorities seem to respond asymmetrically towards currency appreciation, also with both instruments. In Colombia, monetary authorities seem to intervene in the FX market asymmetrically towards currency appreciation, but no evidence of asymmetry was found through interest rate changes.

3 CONCLUDING REMARKS

Inflation Targeting (IT) has disseminated as one of the main monetary policy frameworks since the late-1990's. The first thoughts with respect its underlying theory, mostly based on the work of John Taylor (e.g. (TAYLOR, 2000) and (TAYLOR, 2001)), expected that the functioning of this framework would be subject to the following tripod: (i) inflation target; (ii) interest rate rule; and (iii) flexible exchange rate. Interestingly, it was argued that, in order to an IT regime to work, the interest rate should not respond to exchange rate changes neither should monetary authorities intervene in the market to control—in any sense—the exchange rate trajectory.

Taylor (1993), Taylor (2000), Taylor (2001) recognize that monetary authorities should not mechanically follow a monetary reaction function as the reality is more challenging than an equation can describe. However, the author argues that monetary authorities should not respond to exchange rate changes as, by responding to the output gap, they would be indirectly offsetting the secondary effects of exchange rate changes on prices.

Many EME have adopted an IT regime, in Latin America and elsewhere, but, due to specific characteristics of the international capital flow to which these economies are susceptible (see (CALVO; REINHART, 2002), (PASSARI; REY, 2015), and (REINHART; REINHART; TREBESCH, 2016)), monetary authorities have devoted special attention to the exchange rate behavior. The literature has documented two important findings regarding Latin American economies under IT. First, it has been argued that monetary authorities have intervened considerably in the FX market, more than expected from a canonical IT regime, generally characterized by a "fear of appreciation" (see (BARAJAS *et al.*, 2014), (BERMÚDEZ, 2014), (CÉSPEDES; CHANG; VELASCO, 2014), (GONZÁLEZ, 2017)). Second, part of the literature has estimated Monetary Reaction Functions (MRF) including the exchange rate as an argument. The general conclusion is that interest rate changes respond to exchange rate changes, even when the equation includes the output gap, indicating that the exchange rate is considered in the decision making-process of monetary policy.

Despite the effort made to comprehend the role played by the exchange rate under IT regimes in Latin America, issues regarding FX interventions and regarding potential asymmetries in the behavior of monetary authorities still need to be addressed. The objective of the dissertation was to help fill this gap by studying the main interventions (through the FX market and through interest rate changes) of monetary authorities in light of the role played by the exchange rate. The aim was, in other words, to improve the understanding with regard to the exchange rate for Latin American economies under IT. The main contribution of this dissertation was the attempt to shed light on the connection and/or differences between the two most important ways that monetary authorities have intervened in the market, namely through interest rate changes and through FX interventions. For this purpose, the analysis has incorporated the study of asymmetries in monetary authorities behavior towards the exchange rate. In particular, the frequency and intensity of FX interventions was divided through upper and lower bounds in order to verify potential asymmetries (as shown in Appendix B). With respect to MRF, appreciation/depreciation variables were included in the equation, also in order to verify potential asymmetries towards the exchange rate.

Findings, through the investigation of Brazil, Chile, and Colombia, suggested that the IT regime has worked differently from the canonical prescriptions and, even considering these economies, with similar characteristics when it comes to the exchange rate behavior, capital flows and exports (mainly commodities), the evidence indicated that there has been a variety of IT regimes in Latin America. The exchange rate has played a pivotal role in Latin American IT regimes, but this variable might not be taken into account by monetary authorities for the same reasons. The differences have arisen when the analysis focused on the asymmetry of monetary authorities behavior towards the exchange rate and on the potential explanations behind it.

Several features have been recurrent and coincident in the Brazilian experience: critical periods in which the economy has witnessed exchange rate depreciation, exchange rate volatility increase, acceleration of inflation, detachment of expectations, monetary policy tightening and FX interventions. Results suggested that, both through interest rate changes and through FX interventions, monetary authorities have responded asymmetrically towards exchange rate depreciation, that is, they have been more concerned about currency depreciation and its effects on prices.

Brazilian monetary authorities have been arguing that interventions through interest rate aimed at attenuating secondary effects of exchange rate changes on prices and, through FX interventions, at attenuating exchange rate volatility. This argument is, to some extent, consistent as periods of intense currency depreciation have been also characterized by exchange rate volatility increase and detachment of expectations. However, periods in which monetary policy tightening and FX interventions have hardened the most have been also coincident with periods that Brazilian monetary authorities themselves acknowledged that the pass-through was one of the main relevant components of the inflation outcome. In this vein, although it is hard to separate to which phenomena monetary authorities were responding, the remaining question is whether they have intervened in the market only in order to attenuate the propagation of exchange rate shocks or, besides that, in order to influence somehow the exchange rate trajectory itself. The experiences of Chile and Colombia pointed out to a different behavior of monetary authorities towards the exchange rate. In Chile, interventions in the FX market have not been as frequent as those in Brazil and Colombia, but they have depicted an asymmetry towards currency appreciation, that is, they have been more pronounced throughout periods in which the Chilean peso was gaining value against the dollar. The estimation of MRF also suggested that the response through interest rate changes has been asymmetrical towards currency appreciation. Results, in other words, indicated a "fear of appreciation"—finding in line with that of González (2017)—which was not only different from the Brazilian experience in terms of asymmetry but also in terms of potential reasons behind interventions.

Periods including intense exchange rate appreciation, detachment of expectations, inflation rate below the lower limit, and monetary policy easing have been more frequent in Chile. There have been cases in which intense currency depreciation also influenced the dynamics of domestic prices—acknowledged by Chilean monetary authorities—, but this scenario was not necessarily followed by monetary policy tightening and by substantial interventions in the FX market.

The Chilean case was less controversial than Brazilian and Colombian ones as interventions in the FX market have been much more modest and as monetary authorities have expressed that their main concern with the exchange rate had to do with its influence on the balance of payments. Although FX interventions have been more frequent and intense during periods of currency appreciation, they have been more modest than that of Brazil and Colombia, attenuating the question whether Chilean monetary authorities tried to influence the exchange rate trajectory.

In terms of why monetary authorities might be concerned with exchange rate changes, the Colombian experience is more similar, but not completely so, to the Chilean experience. Interventions in the FX market have also been asymmetrical towards currency appreciation and monetary authorities, through their inflation reports, have expressed more openly their intention to attenuate balance of payments issues. Differently from Chile, however, interventions have been more systematic, and it also arises the question whether there has been an attempt to influence the exchange rate trajectory itself, rather than only attenuating its secondary effects.

The estimation of MRF in Colombia, on the other hand, did not show evidence of asymmetry towards exchange rate changes, i.e. despite the asymmetry found in the FX market towards currency appreciation, the same result was not found with the interest rate. In this vein, the study of these three Latin American economies revealed that, although the exchange rate has played a pivotal role in the conduction of monetary policy, there are three cases.

Brazilian one: in which interventions both through interest rate changes and

through FX interventions have been asymmetrical towards currency depreciation. Monetary authorities have been mostly concerned with the effect of exchange rate changes on prices; the remaining question is whether they were trying to attenuate the propagation of exchange rate shocks or also to influence the exchange rate trajectory itself, say, to attenuate the exchange rate pass-through.

Chilean one: in which interventions both through interest rate changes and through FX interventions have been asymmetrical towards currency appreciation. The reason behind the utilization of these two instruments, however, was not necessarily the same. Chilean monetary authorities have expressed their concern with respect to balance of payments issues, suggesting that FX interventions had to do with it. The moderation of FX interventions in Chile, on the other hand, eliminate the question whether monetary authorities have tried to influence the exchange rate trajectory itself.

Colombian one: in which evidence suggested an asymmetrical behavior of monetary authorities only in the FX market, having interventions occurred frequently and intensively. Also, monetary authorities have expressed more clearly the intention to attenuate balance of payments issues. The Colombian experience, in other words, is the one in which the potential reason why monetary authorities have used these two instruments has been dissociated the most. One could argue that the same was observed in Chile, but it is hard to sustain this hypothesis as FX interventions in this country have been very modest.

The experience of these Latin American economies under IT regime not only scratches the surface of the canonical IT theory because monetary authorities have devoted considerable attention to the exchange rate behavior but also because there is a variety of IT regimes in Latin America, with relevant idiosyncrasies. Considering the regimes as equal in their features is misunderstanding the real functioning of them in each economy. The aim, of course, at keeping the inflation rate low and stable is in the core of the IT regimes, but it has been argued here that the utilization of instruments has varied in terms of intensity, purpose, and asymmetry when it comes to exchange rate changes.

This dissertation encourages further research at least in three directions. First, the analysis here can be extended to other EME, in Latin America and elsewhere. The recent events occurred in Turkey, for instance, indicate a potential importance for the exchange rate in their IT functioning as inflation rate and expectations increased considerably at same period—Benlialper and Cömert (2015) have already investigated the asymmetrical response of monetary authorities towards exchange rate changes through interest rate changes, but understanding FX interventions and their connection/differences with monetary policy is needed.

Second, an econometric research of the FX market in EME may help understand which variables monetary authorities analyze before intervening in the market (i.e. a reaction function for the FX market interventions). Potential variables could be: a proxy for exchange rate misalignment, exchange rate variance, reserves variance, VIX index, S&P index, EMBI index, etc. This second direction is particularly helpful as improves the understanding, in a more profound manner, of the potential intention of monetary authorities in influencing the exchange rate trajectory if, for example, in the reaction function for FX interventions, exchange rate misalignment is significant even when controlled by other variables. Third, since IT regimes in Latin America are more flexible than the canonical theory predicted, the literature needs to address the question about how flexible the regimes can be without undermining monetary authorities' credibility.

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A COMMODITY PRICE INDEX



Figure 13 – Exchange Rate and Commodity

Source: IMF, Brazilian Central Bank, Chilean Central Bank, Banco de la República and author's calculation.

B INTERVENTION ASYMMETRY

Table 10 – Intervention Interval Statistics

	Brazil/Swaps	Chile/Swaps	Chile/Net Sales	Colombia
Mean (μ)	U 19.03 billion	-CLP 107.6 billion	-U\$ 49.77 million	-U\$ 154.73 million
Standard Deviation (σ)	U\$ 37.88 billion	CLP 384.97 billion	U\$ 328.88 million	U\$ 289.18 million
Upper Bound $(\mu + \sigma)$	U 56.9 billion	CLP 277.37 billion	U\$ 279.12 million	U 134.45 million
Lower Bound $(\mu - \sigma)$	-U $\$$ 18.85 billion	-CLP 492.57 billion	-U\$ 378.65 million	-U\$ 443.91 million

Table 11 – Intervention Asymmetry

	Brazil/Swaps	Chile/Swaps	Chile/Net Sales	Colombia
Number of interventions outside the interval (A)	53	23	26	40
Number of interventions above the upper bound (B)	33	4	8	15
Number of interventions below the lower bound (C)	20	19	18	25
B/A	62.3	17.4	30.8	37.5
C/A	37.7	82.6	69.2	62.5
Intervention asymmetry	Depreciation	Appreciation	Appreciation	Appreciation

C MONETARY REACTION FUNCTIONS WITH HAMILTON FILTER

Parameters	Brazil	Colombia	Chile
α_0	-1.35***	1.26^{***}	1.59^{***}
	(-2.77)	(3.96)	(5.68)
α_1	1.09^{***}	0.74^{***}	0.58^{***}
	(28.80)	(11.27)	(8.84)
$lpha_2$	0.26^{***}	0.89^{***}	0.43^{***}
	(3.28)	(2.94)	(3.77)
$lpha_3$	0.06^{***}	0.08***	0.19***
	(3.81)	(4.44)	(6.03)
$lpha_4$	-1.09	0.006***	-0.01
	(-1.00)	(4.21)	(-0.94)
$lpha_5$	2.51^{**}	0.003***	0.02**
	(2.37)	(2.97)	(2.04)
J-statistic (p-value)	0.17	0.58	0.41
R^2	0.96	0.83	0.92
*** Significance at 1%			

Table 12 – Equation 3.1

** Significance at 5%

* Significance at 10%

t-statistics in brackets

Table 13 – Equation 3.2

Parameters	Brazil	Colombia	Chile
1 arameters	DIazii	Colombia	Onne
eta_0	0.17	1.04^{***}	0.28^{**}
	(1.33)	(4.40)	(2.21)
β_1	0.95***	0.80^{***}	0.95^{***}
	(52.92)	(17.65)	(34.2)
β_2	0.33^{***}	0.47^{***}	0.2^{***}
	(9.31)	(3.31)	(3.54)
β_3	0.01^{***}	0.06^{***}	0.001
	(2.82)	(6.11)	(0.05)
eta_4	1.45^{***}	0.006^{***}	-0.004
	(2.89)	(3.60)	(-1.19)
eta_5	-2.78**	0.009^{***}	0.001
	(-2.37)	(3.08)	(0.98)
J-statistic (p-value)	0.08	0.35	0.84
R^2	0.97	0.90	0.97

*** Significance at 1%

** Significance at 5%

* Significance at 10%

t-statistics in brackets

Parameters	Brazil	Colombia	Chile
γ_0	0.42^{***}	1.43^{***}	0.04
	(2.9)	(6.0)	(0.45)
γ_1	0.93***	0.72^{***}	0.99^{***}
	(81.7)	(15.67)	(43.64)
γ_2	0.42^{***}	0.77^{***}	0.21^{***}
	(9.0)	(3.47)	(2.97)
γ_3	0.01^{*}	0.07^{***}	0.01
	(1.79)	(6.05)	(1.34)
γ_4	1.16^{**}	0.002	-0.003
	(1.94)	(1.29)	(-0.51)
γ_5	-3.24***	0.009^{***}	0.01^{***}
	(-3.19)	(5.13)	(3.25)
J-statistic (p-value)	0.42	0.74	0.58
R^2	0.96	0.9	0.97

Table 14 – Equation 3.3

*** Significance at 1% ** Significance at 5% * Significance at 10%

t-statistics in brackets

v