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Asymmetric Exchange Rate Policy in Inflation Targeting Developing Countries

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Abstract

In the last decades, many developing countries abandoned their existing policy regimes and adopted inflation targeting (IT) by which they aimed to control inflation through the use of policy interest rates. During the period before the crisis, most of these countries experienced large appreciations in their currencies. Given that appreciation helps central banks curb inflationary pressures, we ask whether central banks in developing countries have different policy stances with respect to depreciation and appreciation in order to hit their inflation targets. To that end, we analyze central banks' interest rate decisions by estimating a nonlinear monetary policy reaction function for a set of IT developing countries using a panel threshold model. Our findings suggest that during the period under investigation (2002-2008), central banks in developing countries implementing IT tolerated appreciation by remaining inactive in the case of appreciation, but fought against depreciation pressures beyond some threshold. We are unable to detect a similar asymmetric response for IT advanced countries suggesting that an asymmetric policy stance is particular to IT developing countries. Although there is a vast literature on asymmetric responses of various central banks to changes in inflation and output, an asymmetric stance with regards to the exchange rate has not been analyzed yet in a rigorous way especially within the context of IT developing countries. In this sense, our study is the first in the literature and thus is expected to fill an important gap.

Keywords: Inflation Targeting, Central Banking, Developing Countries, Exchange Rates

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1. Introduction

In the years preceding the global crisis of 2008, there had emerged a new consensus on the appropriate framework for monetary policy. According to this consensus, inflation targeting (IT) was considered to be the optimal monetary policy regime in both advanced and developing countries[1]. Following the adoption of IT in some advanced countries, many developing countries also joined the group especially in the beginning of the 2000s.

In the IT framework, the central bank explicitly announces that its primary goal is to ensure price stability and conducts monetary policy in line with the announced inflation targets. The core assumption behind IT is that inflation is mainly a demand driven phenomenon and thus can be dealt with by an appropriate monetary policy. The central bank can affect aggregate demand through its control over short term interest rates and thereby contain inflation. In this line of reasoning, developing countries and advanced countries are assumed to share similar characteristics. Hence, developing and advanced countries are expected to tackle inflation with the same set of tools.

There is an important difference, however, as to the sources of inflation between developing and advanced countries. Supply side factors such as exchange rates and commodity prices appear to play a far greater role in determining inflation in developing countries[2]. This may greatly undermine the crux of the IT framework for developing countries. If the major sources of inflation are related with supply side factors which are generally beyond what monetary policy can easily influence, affecting inflation through the impact of policy interest rates on aggregate demand and expectations may not lead to desired outcomes. In this sense, it is quite likely that inflation targets would be missed due to external conditions such as international commodity prices or exchange rates, eroding the credibility of the IT central bank. True, many countries adopted, in practice, flexible versions of IT including forms of "escape clauses" through which the central bank can opt to do nothing if the failure to achieve the target is related to external shocks. Nevertheless, if these shocks appear too frequently as in the case of many developing countries, possibly leading to "regular" misses, the main tenet of IT, the "credibility" of the central bank, may suffer to a great extent. In this case, an IT central bank may have to resort to other measures in order to hit inflation targets and preserve its credibility. Given the importance of the exchange rate in shaping inflation, then, IT central banks in developing countries may find it useful to utilize the exchange rate implicitly as an additional policy tool.

[1] See, among others, Bernanke et al. (1999), Mishkin (2004).

[2] According to Anwar and Islam (2011), the main sources of inflation in developing countries are sudden supply shocks rather than unsuccessful macroeconomic policy. In the least developed countries, the correlation between inflation and food prices is found to be quite high. In a similar way, Stiglitz (2008) claims that oil and food prices are crucial in developing countries, implying that inflation is mostly "imported" in these countries. Some other authors also resort to econometric techniques to analyze determinants of inflation in developing countries. Mohanty and Klau (2001) find that changes in food prices is the most important source of inflation whereas the exchange rate is found to contribute significantly to inflation in many countries. A similar argument is made for the Philippines by Lim (2006), claiming that oil price changes and exchange rates can explain most of the inflationary pressures in this country. Some studies also find a strong association between exchange rate changes and instances of missed inflation targets (Ho and McCauley, 2003; Roger and Stone, 2005), highlighting the importance of the exchange rate in determining inflation.

During the period before the crisis, many developing countries witnessed appreciation trends in their currencies as Figure 1 illustrates. This clearly helped central banks achieve their targets by easing inflationary pressures coming from elsewhere. However, whether this trend is supported by monetary policy or not is contentious and needs to be investigated carefully. Formally, IT central banks declare that they have floating exchange rate regimes, though they reserve the right to intervene in the case of excessive fluctuations. However, there can always be subtle differences between what central banks claim they are doing and what they actually do. In this sense, the main finding of this paper is that the trend towards appreciation is related with a deliberate policy stance of central banks in developing countries. More specifically, evidence suggests that IT central banks of developing countries adopted an asymmetric policy stance with respect to the exchange rate, tolerating appreciation and fighting against depreciation.

There are several reasons why the utilization of exchange rates can emerge as a panacea for IT central banks. If there is a positive gap between realized inflation and inflation targets in general – i.e. if overshoots occur more frequently than undershoots – the monetary authority can benefit from appreciation of the currency since this puts downward pressure on domestic prices of imported goods. Table 1 indicates that the gap is indeed positive and that the upper bound of the target range is more binding than the lower bound. Approximately in one third of the cases under consideration, an overshoot of the inflation target is observed whereas the number of undershoots remains low[3]. It should also be noted that this gap arises in the presence of strong appreciation trends (Figure 1) which puts a downward pressure on inflation. In the absence of currency appreciation, the magnitude of the gap might have been greater[4].

Table 1 also indicates that success/failure of monetary policy and exchange rate movements can be related to each other as also suggested by Ho and McCauley (2003) and Roger and Stone (2005). In 29 out of 42 overshoot episodes, currencies depreciated. On the other hand, success in hitting the target seems to be associated with appreciation (nearly two thirds of success episodes). This basic analysis suggests that exchange rate movements can be quite important if the focus is on inflation.

Developing countries generally witnessed higher inflation rates compared to their advanced counterparts prior to their adoption of IT. Indeed, many countries implemented IT in an effort to reduce inflation and keep it under control. In this sense, an asymmetric stance with respect to the exchange rate can contribute to the disinflation process. Inflation targets are generally higher in developing countries. Given the mainstream view that inflation should not exceed 2-3 percent, developing country central banks may be willing to reduce their targets gradually.

[3] By the overshoot (undershoot) of the target, we mean that realized inflation moves beyond the upper (lower) bound of the inflation target range.

[4] We should also note that these developments occurred in the background of disinflationary trends in the world economy, sometimes also named "global disinflation". In the absence of such a disinflationary trend, we would expect a more intense use of exchange rate policy by the IT central banks.

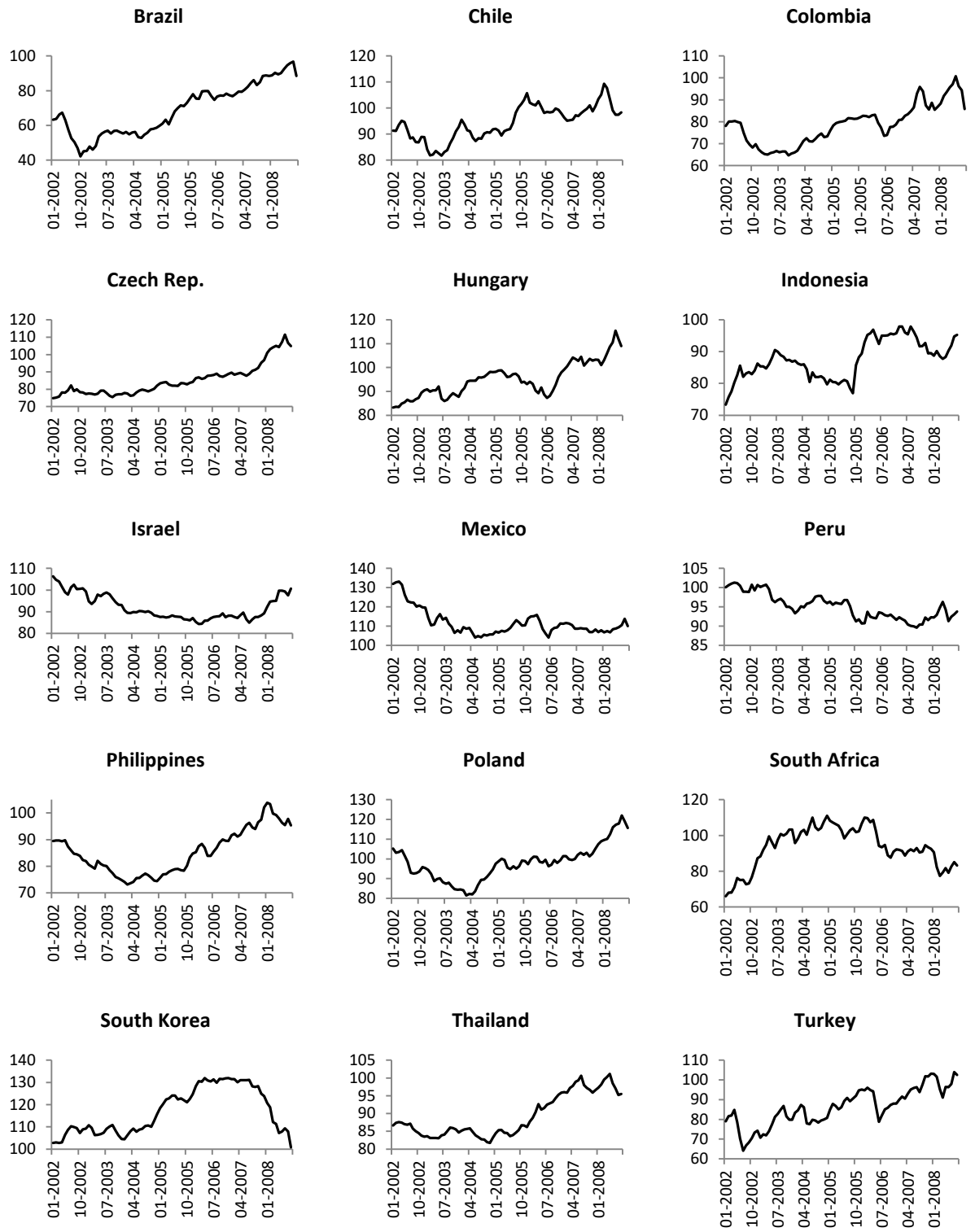

Figure 1. Real effective exchange rates in inflation targeting developing countries (2002-2008). Source: Bank for International Settlements, 2010=100.

		2002	2003	2004	2005	2006	2007	2008	2010	2011	2012	2013
Brazil	Target	1.5-5.5	1.5-6.5	3-8	2-7	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5
	Inflation	12.53	9.3	7.60	5.69	3.14	4.46	5.90	5.91	6.50	5.84	5.91
	Hit/Miss	+	+	o	o	o	o	o	o	O	o	o
	NEER ch.	-6.36	-15.54	1.66	18.26	11.06	7.97	4.31	11.96	1.94	-11.07	-7.96
Chile	Target	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4
	Inflation	2.82	1.07	2.43	3.66	2.57	7.83	7.09	2.97	4.44	1.49	3.01
	Hit/Miss	o	-	o	o	o	+	+	o	+	-	o
	NEER ch.	-2.60	-4.68	6.23	7.34	4.02	-3.35	-2.02	7.15	1.27	3.51	0.55
Colombia	Target	6	5-6	5-6	4.5-5.5	4-5	3.5-4.5	3.5-4.5	2-4	2-4	2-4	2-4
	Inflation	7	6.49	5.50	4.85	4.48	5.69	7.68	3.18	3.73	2.44	1.93
	Hit/Miss	o	+	o	o	o	+	+	o	O	o	-
	NEER ch.	-3.17	-11.88	7.96	12.06	-2.28	10.00	3.80	12.75	4.14	5.92	-0.02
Czech Rep.	Target	2.75-4.75	2.5-4.5	2.25-4.25	2-4	2-4	2-4	2-4	1-3	1-3	1-3	1-3
	Inflation	0.64	1.06	2.71	2.24	1.69	5.47	3.61	2.30	2.42	2.37	1.40
	Hit/Miss	-	-	o	o	-	+	o	o	O	o	O
	NEER ch.	11.62	-0.04	0.71	6.16	5.15	2.83	12.44	2.07	3.15	-3.85	-1.69
Hungary	Target	3.5-5.5	2.5-4.5	2.5-4.5	3-5	2.5-4.5	2-4	2-4	3	3	3	3
	Inflation	4.80	5.70	5.50	3.30	6.50	7.40	3.50	4.65	4.10	5.00	0.40
	Hit/Miss	o	+	+	o	+	+	o	+	+	+	-
	NEER ch.	7.06	-0.16	2.11	0.79	-6.08	6.03	1.37	-0.57	-0.87	-5.32	-1.03
Israel	Target	2-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
	Inflation	6.49	-1.88	1.20	2.38	-0.09	3.39	3.80	2.66	2.17	1.63	1.81
	Hit/Miss	+	-	o	o	-	+	+	o	O	o	O
	NEER ch.	-12.52	-3.71	-3.37	-0.94	0.22	3.38	11.09	4.82	1.15	-3.97	7.21
Mexico	Target	4.5	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4
	Inflation	5.70	3.98	5.19	3.33	4.05	3.76	6.53	4.40	3.82	3.57	3.97
	Hit/Miss	+	o	+	o	+	o	+	+	O	o	O
	NEER ch.	-3.31	-12.62	-5.90	3.26	-0.68	-2.27	-2.83	6.10	0.13	-4.76	3.85
Peru	Target	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	2-3	2-3	2-3	2-3	1-3	1-3
	Inflation	1.52	2.48	3.48	1.49	1.14	3.93	6.65	2.08	4.74	2.65	2.86
	Hit/Miss	o	o	o	-	-	+	+	o	+	o	O
	NEER ch.	6.15	-0.99	-1.69	0.35	-0.96	0.18	3.24	4.92	-0.79	7.42	-0.01
Philippines	Target	4.5-5.5	4.5-5.5	4-5	5-6	4-5	4-5	3-5	3.5-5.5	3-5	3-5	3-5
	Inflation	2.07	2.51	7.11	5.88	4.11	3.65	7.81	3.64	4.16	2.98	4.11
	Hit/Miss	-	-	+	o	o	-	+	o	O	-	O
	NEER ch.	-1.39	-9.34	-6.87	0.81	6.74	7.78	-0.84	2.53	-1.04	3.66	2.75
Poland	Target	4-6	2-4	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5
	Inflation	0.80	1.70	4.40	0.70	1.40	4.00	3.30	3.10	4.60	2.40	0.70
	Hit/Miss	-	-	+	-	-	+	o	o	+	o	-
	NEER ch.	-4.11	-9.50	-1.99	11.79	3.37	4.06	9.47	5.70	-2.60	-3.66	1.42
South Africa	Target	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6
	Inflation	12.43	0.33	3.45	3.58	5.76	9.00	10.07	3.48	6.05	5.71	5.40
	Hit/Miss	+	-	o	o	o	+	+	-	+	o	O
	NEER ch.	-20.38	25.62	9.09	0.33	-6.02	-9.86	-16.99	13.35	-3.66	-8.35	-13.70
Turkey	Target	35	20	12	8	5	4	4	6.5	5.5	5	5
	Inflation	29.71	18.40	9.36	7.72	9.65	8.39	10.06	6.40	10.45	6.16	7.40
	Hit/Miss	-	-	-	o	+	+	+	o	+	+	+
	NEER ch.		-11.60	-2.30	4.31	-7.12	2.50	-4.12	3.98	-14.01	-2.10	-6.33

Table 1. Inflation targets, success/failure indicators, exchange rates in selected IT developing countries.

Source: Central banks, IMF WEO, IMF IFS, BIS[5].

[5] Notes: + (-) represents overshoot (undershoot) whereas "o" represents success of hitting the target. The crisis year, 2009, was excluded from the table. For countries where there is a point target, it is assumed that the central

Hence, they may remain reluctant in the case of undershoots since this may change expectations over future inflation and helps to achieve lower inflation targets in the future[6]. An overshoot, on the other hand, may deteriorate future inflation expectations and hinder disinflation efforts. This scenario, then, also explains the lax stance with respect to undershoots and tight responses in case of overshoots. This again can necessitate an asymmetric exchange rate policy of the central bank. Given the relative ineffectiveness of monetary policy in developing countries arising either from the importance of supply side factors as determinants of inflation or from bottlenecks in the monetary transmission mechanism, utilization of the exchange rate as an implicit policy tool may become imperative for the developing country central banks in order to curb inflation, meet the targets and also lower the targets gradually[7,8].

In order to test whether IT central banks in developing countries responded to exchange rate changes asymmetrically, we analyze central banks' interest rate decisions by estimating a nonlinear monetary policy reaction function for a set of developing countries using a panel threshold model. Evidence suggests that whereas central banks respond to depreciation pressures beyond some threshold, they remain inactive with respect to appreciation. Hence, the analysis of central banks' policy response in interest rate decisions reveals that the policy stance in IT developing countries with respect to exchange rate movements is asymmetric favoring appreciation[9]. We are unable to detect a similar asymmetric response for IT advanced countries suggesting that an asymmetric policy stance is peculiar to IT developing countries.

There is a vast literature on asymmetric responses of various central banks to changes in inflation and output. However, an asymmetric stance with regards to the exchange rate has not been analyzed yet in a rigorous way. Some previous studies asserted that the policy may indeed be asymmetric without providing any econometric evidence (Bristow, 2012; Barbosa-Filho, 2008). Some other authors analyze individual countries and validate the asymmetric

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bank is successful if inflation remains within a one percent neighbourhood of the point target. The exchange rate data is annual percentage change of nominal effective exchange rate.

[6] Moreover, given that lower bounds of the target are generally not close to zero, undershoots of the target do not lead to deflation, partially explaining the irresponsiveness of monetary authorities.

[7] One of the most striking official declarations recognizing the inability of conventional monetary policy implementation in containing inflation and underlining the possible role of the exchange rate comes from the non-IT central bank of Singapore: "MAS (Monetary Authority of Singapore) has found the exchange rate to be the most effective instrument to keep inflation low. Other possible intermediate targets, in particular interest rates, are less effective in influencing real economic activity and domestic inflation outcomes" (MAS, 2001: 17).

[8] There are also other factors which can partially explain an asymmetric policy stance. If the exchange rate pass through is asymmetric in the sense that the pass through coefficient is higher in depreciations compared to appreciations (Delatte and Lopez-Villavicencio, 2012), then an IT central bank naturally responds asymmetrically to these movements. On the other hand, Kumhof (2000) emphasizes the importance of sticky prices of non-tradable goods in small open economies which struggle with credibility problems, a typical case in developing countries. In this case, imperfect credibility of the central bank leads to an endogenous policy response, monetary tightening, to prevent currency depreciation in order to meet the target.

[9] It is worth mentioning that what we refer to as an asymmetric policy stance does not require the central bank to be constantly intervening in order to appreciate the currency. Rather, we claim that when capital inflows continued, IT central banks tolerated the concomitant appreciation trend whereas they responded to depreciation pressures when the trend reversed. Hence, an asymmetric policy response is likely to emanate from the difference in the degree of tolerance of central banks with respect to the direction of the exchange rate changes.

nature using econometric techniques (Benlialper and Cömert, 2016b; Galindo and Ros, 2008; Libanio, 2010)[10]. In contrast with these studies, we test this hypothesis using formal nonlinear time series techniques. Moreover, in contrast with individual country studies, we generalize the hypothesis to the set of IT developing countries by using panel data. Hence, rather than analyzing individual country cases, our aim is to uncover a general characteristic feature of IT implemented in developing countries. In this sense, our study is the first in the literature and thus fills an important gap.

The outline of the paper is as follows. In the next section, we briefly review the literature on monetary policy rules and present our model and data. In the third section, we analyze estimation results of monetary policy reaction functions of several IT developing countries in order to investigate whether they respond asymmetrically to the exchange rate. In this section, we also replicate our analysis for advanced countries implementing IT. The fourth section concludes.

2. Asymmetries in the Interest Rate Setting Decision: Implications of a Nonlinear Monetary Policy Rule

Since Taylor (1993) proposed a simple monetary policy rule designed for the Federal Reserve, there have been numerous studies analyzing monetary policy reaction functions of different central banks. In particular, the literature has expanded in mainly three directions. First, following Clarida et al. (2000), assuming a forward looking monetary policy rule has become widespread in empirical studies. Second, many studies incorporated the exchange rate in the monetary policy reaction functions of central banks. Lastly, there has emerged a strand of literature looking for asymmetries in central banks' interest rate setting decisions. In this study, we will benefit from the last two strands of the literature in order to evaluate the response of IT developing countries to movements in the exchange rate.

The inclusion of the exchange rate in the monetary policy rule is a contentious issue in the relevant literature. On the one hand, some authors claim that exchange rate considerations are already present in a central bank's policy decisions if it takes into account the impact of changes in the exchange rate both on output and inflation when setting interest rates (Taylor, 2001). Thus, there is no need for including the exchange rate directly in the monetary policy rule. This is the standard mainstream open economy IT approach to the exchange rate in advanced countries which is called "Plain Vanilla Inflation Targeting". On the other hand, some other authors suggest that a central bank may respond directly to exchange rate movements rather than waiting for its impact on inflation and output to materialize (Edwards, 2006). It is argued that whether or not the central bank responds directly to the exchange rate is a country-specific issue and should be analyzed empirically for each case (Edwards, 2006).

[10] We should also mention that there are studies suggesting an asymmetric nature in the reverse direction, namely that appreciation pressures are contained more than depreciation pressures (Pontines and Siregar, 2012; Rajan, 2012; Levy-Yevati and Sturzenegger, 2013). However, these studies (excluding the latter) concentrate on the experience of Asian countries which are generally known to put great emphasis on competitiveness in international trade. The case of East and South East Asian countries is in stark contrast with our sample regarding the priorities of their central banks. What we claim in study is that "IT" central banks are inclined to exhibit an asymmetric policy due to various reasons discussed above.

In this vein, Benlialper and Cömert (2016b) identify the distinguishing characteristics of developing countries and count mainly three reasons why IT central banks are likely to include the exchange rate explicitly in their reaction functions especially in developing countries[11].

The first reason is related to the need for preserving the credibility of the IT regime. As some empirical work documents, the exchange rate is an important determinant of inflation in developing countries (Mohanty and Klau, 2001; Benlialper and Cömert, 2016b). Given that developing countries suffer from larger and more persistent exchange rate shocks compared to their advanced counterparts, the likelihood of missing the inflation target in developing countries is higher (Mohanty and Klau, 2004). Hence, in order to preserve their credibility, developing country central banks may have to respond more directly to exchange rate fluctuations.

Moreover, the channel through which exchange rate movements affect inflation (through import prices) works faster than conventional monetary policy channels (Svensson, 1999). Thus, in principle, central banks can use this direct exchange rate channel in order to control inflation rather than waiting for the impact of interest rate decisions on inflation to materialize through the aggregate demand channel. Svensson (2000) suggests that strict IT may require the intense use of the direct exchange rate channel to stabilize inflation in a relatively short horizon. Ball (2000) also recognizes this channel and contends that central banks may resort to this channel if they are given a mandate to keep inflation close to their target. This argument is particularly valid in developing countries which, especially in the beginning of the adoption of IT, try to establish their credibility. Given that the credibility of the central bank is the core of an IT regime, these countries mostly adopted a stricter version of IT in order to establish and preserve their credibility. Thus, they mostly focus on keeping inflation as close as possible to their inflation target in shorter horizons rather than targeting inflation in longer horizons. This requires an intense use of the direct exchange rate channel.

Lastly, the argument for exclusion of the exchange rate in the monetary policy rule depends on an implicit assumption that the interest rate policy is effective in achieving the policy goals. However, there are constraints on the effectiveness of monetary policy in developing countries due to weaknesses in the monetary transmission mechanism[12]. Thus, relying on the aggregate demand channel to control inflation may prove inadequate in the case of developing countries. Given the importance of the exchange rate as a source of inflation, then, central

[11] These reasons are related with the importance of the exchange rate in an IT framework. However, developing countries may need to keep a watchful eye on the exchange rate beyond inflation concerns. Most notably, the exchange rate is crucial for competitiveness and also for ensuring financial stability since dramatic changes in the exchange rate may trigger bank failures especially in developing countries. In this sense, the approaches of developing countries and advanced countries to IT differ for various reasons other than inflation related concerns (Ho and McCauley, 2003). However, in this study we mainly focus on concerns regarding inflation for our purposes.

[12] Mishra and Montiel (2012) and Mishra et al. (2010) give a detailed account of bottlenecks of the monetary transmission mechanism in low-income countries. Although their analysis focuses on low-income countries, developing countries also share some of these characteristics. Hence, to some extent, their analysis is applicable to developing countries as well.

banks in developing countries may resort to the exchange rate channel which may not only be faster but also more effective than the conventional aggregate demand channel.

In sum, developing country central banks which implement IT have several reasons to include exchange rate movements directly in their policy rules. However, as Edwards (2006) emphasizes, this claim should be tested empirically. In fact, many studies verify the existence of the exchange rate in the monetary policy rule both for IT and non-IT countries[13]. Our estimation results for developing countries also show that exchange rate concerns are valid in the monetary policy rule.

The existing literature that includes the exchange rate in the reaction function of the central bank adopts a linear policy rule in which depreciations and appreciations are given the same response in magnitude. On the other hand, there is a large literature on asymmetric behavior of central banks with respect to inflation and output gap. Many studies find that central banks respond asymmetrically either to inflation or to output gap. More specifically, it is found that some central banks respond more strongly to negative output gaps than to positive gaps[14]. In a similar way, the response to positive inflation gaps is found to be higher compared to negative inflation gaps revealing the inflation avoidance of central banks[15, 16]. In this study, we will benefit from the literature on nonlinear policy rules and extend it to incorporate nonlinear responses to exchange rate movements. To the best of our knowledge, this has not been attempted previously. Moreover, in contrast to the bulk of the literature, we analyze a panel of countries rather than individual countries. In the following part, we present our model and discuss its basic properties.

The model

Our model for the monetary policy reaction function that we will use for empirical purposes is fairly standard in the literature. We assume that a central bank moves policy rates in response to the inflation gap, output gap and changes in the exchange rate. Ball (1999) and Aizenman et al. (2011) derive an optimal policy response in open economies and show that the optimal rule includes the exchange rate[17]. We follow this approach and construct the model for the individual country in the following way:

[13] Filosa (2001) and Mohanty and Klau (2004) indicate that monetary authorities in developing countries (both IT and non-IT) strongly react to fluctuations in the exchange rate. There are also studies which focus exclusively on the policy reaction of IT developing countries. For instance, Ho and McCauley (2003) contend that developing countries are likely to respond to the exchange rate in an IT framework. Aizenman et al. (2011) find that policy interest rates respond significantly to real exchange rate variations in IT developing countries.

[14] Gerlach (2000), Cukierman and Mustacelli (2008), Surico (2003), Bunzel and Enders (2010).

[15] Martin and Milas (2004), Cukierman and Mustacelli (2008), Sznajderska (2014), Castro (2011), Bunzel and Enders (2010).

[16] The finding presented by Dolado et al. (2005) contradicts with the rest of the literature in that they find that the response is higher when inflation or output are above target. On the other hand, there are also studies revealing that the response to the inflation gap (output gap) is asymmetric contingent upon the state of the output gap (inflation gap) (Castro, 2011; Bec et al., 2002).

[17] In Ball (1999) the optimal policy rule requires the use of both interest rate and exchange rate as policy instruments. However, it is straightforward to change the equation so that the exchange rate is in the right hand side of the equation implying that the central bank adjusts interest rates in response to exchange rates as Ball (2000) also mentions.

$$i_t = \alpha_0 + \alpha_1 i_{t-1} + \alpha_2 \pi_t^g + \alpha_3 y_t^g + \alpha_4 \Delta e_t + u_t \qquad (1)$$

where i_t (i_{t-1}) represents policy rate at time t $(t-1)$[18], π_t^g represents inflation gap, y_t^g stands for output gap and Δe_t denotes percentage change in the exchange rate.

The above model has some differences when compared with those in the literature. First, the inflation gap is generally defined as the gap between observed inflation and the inflation target of the central bank. Most of the empirical work focusing on monetary policy rules in IT countries assume that the inflation target is constant over time. Hence, while estimating the policy rule they take inflation as the explanatory variable instead of a measure of the inflation gap by arguing that a constant inflation target is subsumed in the intercept (Aizenman et al., 2011, Hammermann, 2008). However, in the case of developing countries where the inflation target changes significantly (especially for countries which are in a disinflation process during the implementation of IT such as Turkey), this approach may be misleading[19]. In IT regimes, it is the deviation of inflation from the target not the inflation level itself that is responded to by the central bank. Thus, instead of taking targeted inflation as time invariant, we construct an inflation gap variable as follows[20]:

$$\pi_t^g = \pi_t^a - \pi_t^t \qquad (2)$$

where π_t^a is the 12 month inflation at time t and π_t^t is the targeted inflation level which is taken as constant over the months of the same year but varies among years.

The second important characteristic of the policy rule above is that the exchange rate enters the monetary policy rule as percentage change as in Aizenman et al. (2011) instead of in level form or as deviation from equilibrium exchange rate as in Taylor (2001). As opposed to Aizenman et al. (2011), we use nominal exchange rate in the estimation as it reflects inflationary concerns more directly, whereas the real exchange rate is used for a robustness check.

The model in equation (1) is linear. The linearity of the monetary policy rule ensues from the assumption of a quadratic loss function of the central bank together with a linear system describing the economic structure. However, there are many counter-studies rejecting a linear Taylor rule[21]. In this regard, in order to detect possible asymmetries in the reaction function, we transform the linear model in such a way that the central bank can change its attitude to exchange rate movements beyond some threshold value. In the theoretical literature, it is well

[18] The presence of a lagged interest rate term in the policy rule reflects the interest rate smoothing tendency of central banks and is common in the literature since Clarida et al. (2000).

[19] As Table 1 shows, targets are adjusted frequently in some countries. We should also note that Aizenman et al. (2011) are aware of this problem and they also use a very similar inflation gap variable in their estimations.

[20] Some studies take the inflation gap variable as the explanatory variable, however they take the inflation target as the associated value of the trend of inflation calculated using Hodrick-Prescott filter (Leiderman et al., 2006). Given that IT central banks respond to inflation considering target values and these targets are available from central banks' websites and annual reports, we avoid using trend inflation as a proxy for inflation target.

[21] Departing from the conventional quadratic loss function assumption, Bec et al. (2002), Surico (2003), Cukierman and Muscatelli (2008) show that central bank's policy reaction is nonlinear. On the other hand, by adopting a nonlinear Phillips curve, Dolado et al. (2005) demonstrate that an interaction variable of inflation and output is included in the monetary policy rule leading to nonlinear policy response.

established that if the central bank has asymmetric preferences with respect to output gap or inflation, then the optimal monetary policy rule is nonlinear. In this sense, our study is similar to the threshold models of Bec et al. (2002) and Bunzel and Enders (2010). The difference lies in that, whereas they take output gap and inflation as threshold variables respectively, our focus is the exchange rate.

Taking into account that we also use panel data regression techniques, we have the following panel threshold model:

$$i_{i,t} = \alpha_i + \alpha_1 i_{i,t-1} + \alpha_2 \pi^g_{i,t} + \alpha_3 y^g_{i,t} + \alpha_4 I(\Delta e_{i,t} \geq \gamma)\Delta e_{i,t} + \alpha_5 I(\Delta e_{i,t} < \gamma)\Delta e_{i,t} + u_{it} \qquad (3)$$

in which I is the indicator function taking a value 1 if the statement is true and 0 otherwise; α_i represents country specific fixed effects; $i_{i,t-1}$, $\pi^g_{i,t}$, $y^g_{i,t}$ are regime independent variables; u_{it} are assumed to be independent and identically distributed error terms with zero mean and $\Delta e_{i,t}$ is both the regime dependent variable and the threshold variable with threshold value γ. Thus, in the baseline model the exchange rate has two roles. It has an indirect effect as the regime switching threshold variable and a direct effect as the regime dependent explanatory variable. Following Hansen (1999), in order to focus on our main variable of interest, we take the exchange rate as the only regime dependent variable for the benchmark model. Later, we will relax this assumption and analyze the case in which all explanatory variables are regime dependent.

The data

Our sample consists of 12 IT developing countries: Brazil, Chile, Colombia, Czech Republic, Hungary, Israel, Mexico, Peru, the Philippines, Poland, South Africa and Turkey[22]. The sample is chosen on the basis of their adoption dates of IT so that all countries in the sample were implementing IT during the whole period of analysis (2002:1-2008:9)[23]. The specific choice of 2002 is related with the fact that many countries in the sample started implementing IT in the beginning of 2000s: Hungary (2001), South Africa (2000), Turkey (2002), Mexico (2001), Peru (2002), the Philippines (2002). Our dataset ends at September 2008. The reason is that, beginning from this month, the crisis had a huge impact on the economies of developing countries and the main motives of central banks' actions in the aftermath of the crisis were related with the desire to protect their economies from the spillovers of the crisis.

[22] The inclusion of Israel in a developing country set may be contentious. However, the results without Israel do not have a noticeable difference. We also include Turkey which adopted IT formally in 2006. The reason is that, Turkey adopted implicit IT in 2002, the core of which was same as that of full-fledged IT. Moreover, some countries which were implementing IT in this period are excluded from our dataset. Korea and Thailand are excluded because they were taking core inflation as the target variable. Core inflation is relatively more stable and less affected by external developments such as the exchange rate and commodity price changes compared to headline inflation. Thus, it is a more controllable measure of inflation, reducing the need for utilization of the exchange rate. We also exclude Indonesia which started implementing IT implicitly in 2000 since this country used base money as the main monetary policy instrument which is ultimately replaced with "BI rate" as of 2005.

[23] This choice is based on our desire to apply a balanced panel. Other countries that started implementing IT after 2002 are Guatemala (2005), Romania (2005), Serbia (2006), Slovakia (2005), Armenia (2006), Albania (2009), Georgia (2009). The choice of the time period is also consistent with our desire to analyze a relatively homogenous era in the world economy with no structural breaks.

Moreover, the monetary policy framework of developing countries changed considerably after the first shock. Although some of them call their framework an "enhanced" version of IT and most of them declare that their main aim is still keeping inflation close to target, concerns over financial stability seem to drive the conduct of monetary policy after the global economic crisis[24].

In the regression model we have four variables for each country: a measure of output gap, inflation gap, exchange rate and policy interest rate. We use monthly data in the estimations. The dataset starts at 2002:1 and ends at 2008:9 giving us 80 observations for each country after excluding first lags of each variable. Inflation data (consumer price inflation) were obtained from central banks or national statistical institutions. The inflation gap is defined as in equation (2). Inflation targets for each country in each year were taken from central banks' websites, their annual reports and numerous papers analyzing the IT experience of developing countries. In cases where the inflation target is a range rather than a point, we take the average of the lower and upper bound of the range as the associated target.

We use nominal effective exchange rate (NEER) data from the BIS for the exchange rate. Interest rates were obtained from central banks' databases. In contrast with some of the literature which takes short-term interest rates as a proxy for policy rates, we use the official policy rates of central banks[25]. In constructing the monthly data, we implemented the following process: if the decision over the policy interest rate is made in the first half of the month, we take the new value as the policy rate of the corresponding month. However, if the change occurs in the second half of the month, we take the new value as the policy rate of the next month. As a proxy for output we use the monthly industrial production index released by national statistical institutes[26]. Then, the output gap is calculated as the percentage deviation of the seasonally adjusted monthly industrial production index from its trend value which is calculated by the Hodrick-Prescott filter.

3. Estimation results

Before presenting our estimation results, we first analyze whether any of the variables have a unit root process. We use the four most popular panel unit root tests and present the test results in the Appendix, Table A.1. According to the results, the interest rate and the inflation

[24] Interested readers are referred to Hahm et al. (2011), Moreno (2011), Benlialper and Cömert (2016a), Terrier et al. (2011) and Zhang and Zoli (2014) for the components of the new policy framework in developing countries. Filardo et al. (2011) analyze in detail the importance of the exchange rate in the new monetary policy framework of developing countries in the post crisis period. In line with these new developments, in the new period, developing country central banks have kept a watchful eye on the exchange rate, the stability of which is crucial for ensuring financial stability. Accordingly, it is likely that their policy responses to the exchange rate extended beyond inflation concerns and incorporated financial stability concerns. Thus, the arguments for an asymmetric monetary policy stance with respect to the exchange rate are likely to be undermined in the new era.

[25] In Mexico, the target level for banks' balances at the central bank, known as corto, was the operational target until 2008. In the absence of an explicit policy rate we used the weighted average of the bank funding rate as a proxy for the policy rate for the period before 2008. Robustness check results also show that excluding Mexico from the dataset does not have a considerable impact on the results.

[26] For the Czech Rep., Hungary and Poland we used the monthly manufacturing production index available from Eurostat; for Mexico we used OECD data. We were unable to find monthly industrial production data for the Philippines. Instead, we disaggregated seasonally adjusted quarterly GDP data into monthly data through cubic spline interpolation. Then, we calculated the output gap using this transformed data.

gap are likely to exhibit a unit root process. Hence, we use the first difference of both variables. Moreover, we assume that the interest rate responds to lagged values of explanatory variables[27]. Then, the empirical version of the policy reaction function to be estimated is the following panel threshold model:

$$\Delta i_{i,t} = \alpha_i + \alpha_1 \Delta \pi^g_{i,t-1} + \alpha_2 y^g_{i,t-1} + \alpha_3 I\left(\Delta e_{i,t-1} \geq \gamma\right) \Delta e_{i,t-1} + \alpha_4 I\left(\Delta e_{i,t-1} < \gamma\right) \Delta e_{i,t-1} + u_{it} \quad (4)$$

The above model suggests that changes in policy interest rates are explained by the level of output gap, changes in the inflation gap and the exchange rate. However, interest rate changes respond to exchange rate movements nonlinearly. For movements greater than some threshold γ, the coefficient for the response to the exchange rate is α_3; whereas for smaller values it is α_4. The estimated model in equation (4) is the baseline model; however, we also test for the case where the interest rate and/or inflation gap do not follow a unit root process since some test results may be interpreted that way. The results of these specifications will be given later in this section as a robustness check.

In the estimation process of equation (4), following Bunzel and Enders (2010), we use Bruce Hansen's methodology for estimation and for testing the nonlinearity assumption. However, since our data has a panel nature, we use the estimation process suggested by Hansen (1999) which is designed for non-dynamic panel data. Following the steps described in Hansen (1999: 348-349), individual effects α_i are eliminated and for any given threshold γ, the sum of squared errors are found by least squares estimation. Then, using a grid search procedure, the threshold value γ which yields the minimum sum of squared errors is chosen. In empirical studies, it is common to eliminate some candidate values for the threshold value in order to leave enough observations in each regime. Accordingly, we trim 10% of both ends of the threshold variable (percentage change of exchange rate) while searching for the threshold value. In order to test whether our nonlinear specification is correct, we use the bootstrap method of Hansen (1999) since under the null hypothesis of no threshold, γ is not identified, preventing the use of standard testing procedures. Thus, we bootstrap the likelihood ratio (LR) statistic using 1000 replications and calculate the bootstrap estimate of the p-value for the sample value of the LR statistic. A small p-value supports the rejection of the linear (single threshold) model in favor of the single threshold (double threshold) model. We also check for the presence of a double threshold effect. In most specifications including robustness check results, the results do not support the double threshold effect with very high p-values.

The estimation result of equation (4) is given below:

[27] The reason follows straightforwardly from our construction of the monthly policy interest rate variable. If the interest rate change occurs in the first (second) half of the month, it is quite likely that the central bank is responding to conditions occurred in the previous (current) month. We also checked for the case where explanatory variables enter into the equation without lag. The results are robust to this specification.

Threshold estimate	Regime independent variables ($\Delta\pi^{g}_{i,t-1},\ y^{g}_{i,t-1}$)	Regime dependent variable ($\Delta e_{i,t-1}$)	LR test statistic	p-value
$\gamma = -2.24$	$\alpha_1 = 0.145$ (0.018) (0.041) $\alpha_2 = 0.018$ (0.007) (0.007)	$\alpha_3 = -0.006$ (0.011) (0.013) $\alpha_4 = -0.060$ (0.011) (0.025)	9.80 $(7.19)^a$ $(9.22)^b$ $(14.71)^c$	0.038* 0.700**

Table 2. Estimation results for the baseline model.
Standard errors and White-corrected standard errors are given in parentheses, respectively.
a, b, c: 10%, 5%, 1% critical values, respectively.
* p-value for the single threshold model.
** p-value for the double threshold model.

The results indicate that central banks respond to depreciations greater than 2.24% ($\alpha_4 = -0.060$) whereas they remain quite unresponsive to any other exchange rate movement including both appreciations and small depreciations given that the high regime coefficient is very close to zero ($\alpha_3 = -0.006$) and statistically insignificant. On the other hand, results also reveal that central banks remain relatively unresponsive to the output gap ($\alpha_2 = 0.018$), whereas they strongly react to inflation as evidenced by the high coefficient of the inflation gap ($\alpha_1 = 0.145$) implying that the major consideration of central banks is inflation in IT developing countries. Test results also show that the single threshold effect is significant with bootstrap p-value 0.038 providing evidence for the nonlinear structure of the model.

Overall, our estimation results demonstrate the depreciation avoidance of IT central banks in developing countries. Hence, the policy stance with respect to exchange rate seems to be asymmetric in the sense that central banks tolerate appreciation and remain unresponsive to small depreciations; but whenever depreciation reaches beyond some threshold, they fight against this pressure. In the following part, we explore whether these results are robust under different specifications.

Robustness checks

In this part, we estimate the model given in (4) under several different specifications. First, we change the definition of inflation gap and introduce monthly varying inflation targets as opposed to the baseline case in which the inflation target was assumed to be constant for each month of the same year. By allowing the inflation target to change for each month, we assume that the central bank may have a target path throughout the year and it does not have to hit the annual target each month. The details of the construction of monthly targets are given in the appendix. After calculating monthly targets, we use equation (2) in order to construct the inflation gap variable. The results with the new inflation gap variable are presented in the first column of Table 3. We also checked for the case where the inflation gap is stationary. Hence, instead of taking first difference of the inflation gap, we let it enter into equation (4) in its original form. The results of this change are reported in column 2.

The exchange rate variable is central to our analysis. Thus, we checked the validity of the results under different scenarios regarding the exchange rate. First, instead of using the month to month percentage change, the change in the exchange rate is defined as the percentage deviation of the exchange rate at the current period from its moving average over the previous two months. Mathematically, the new variable for each country is:

$$\Delta e_t = (e_t/(\frac{1}{2}\sum_{i=t-2}^{t-1} e_i) - 1) * 100 \qquad (5)$$

Then, we used real effective exchange rate data (REER, source: BIS) instead of NEER in the estimation process. The results using new exchange rate variables are given in columns 3 and 4. Moreover, we re-estimated model (4) without Israel and Mexico[28]. The results with 10 countries are available in column 5 of Table 3. Lastly, we estimated a slightly modified version of model (3) given that the interest rate may not exhibit unit root process as some tests suggest. The results of this change are given in column 6.

	1	2	3	4	5	6
γ	-2.24	-2.24	-3.02	-0.94	-2.39	-2.24
$\Delta\pi^g_{i,t-1}$	0.090 (0.018) (0.033)	-	0.142 (0.017) (0.034)	0.149 (0.018) (0.041)	0.138 (0.018) (0.043)	0.101 (0.018) (0.030)
$y^g_{i,t-1}$	0.022 (0.007) (0.007)	0.022 (0.007) (0.007)	0.018 (0.007) (0.006)	0.018 (0.007) (0.007)	0.021 (0.008) (0.008)	0.016 (0.007) (0.006)
$I(\Delta e_{i,t-1} \geq \gamma)\Delta e_{i,t-1}$	-0.006 (0.012) (0.013)	-0.002 (0.012) (0.014)	-0.011 (0.009) (0.010)	0.002 (0.013) (0.015)	-0.001 (0.012) (0.013)	0.003 (0.011) (0.013)
$I(\Delta e_{i,t-1} < \gamma)\Delta e_{i,t-1}$	-0.060 (0.011) (0.025)	-0.064 (0.012) (0.026)	-0.050 (0.009) (0.020)	-0.058 (0.012) (0.023)	-0.053 (0.012) (0.027)	-0.073 (0.011) (0.024)
$\pi^g_{i,t-1}$	-	-0.012 (0.006) (0.012)	-	-	-	-
$i_{i,t-1}$	-	-	-	-	-	0.964 (0.004) (0.009)
LR test stat.	9.30	11.76	8.45	8.44	8.43	20.68
p-value (single threshold)	0.047	0.027	0.085	0.074	0.066	0.004
p-value (double threshold)	0.706	0.954	0.220	0.140	0.751	0.738

Table 3. Robustness check results.
Standard errors and White-corrected standard errors are given in parentheses, respectively.

[28] See footnotes 23 and 26 for this consideration.

The results reveal that the main conclusion we draw from the baseline model is preserved under different specifications. In all regressions, an asymmetric response to exchange rate movements is clear with the threshold varying from -2.24 to -2.39 for the baseline measure of exchange rate movements (monthly percentage change of NEER)[29]. Moreover, in most of the cases central banks appear to respond to the inflation gap whereas the coefficient of the output gap remains very low. All of the nonlinearity test results indicate the existence of nonlinearity with bootstrap p-values smaller than 0.10 (smaller than 0.05 for some specifications).

We also let all variables in equation 4 be regime dependent. Since estimation results suggest us to use double threshold in this case, we analyze the following model:

$$\Delta i_{i,t} = \alpha_i + \alpha_1 I(\Delta e_{i,t-1} \le \gamma_1)\Delta\pi^g_{i,t-1} + \alpha_2 I(\gamma_1 < \Delta e_{i,t-1} \le \gamma_2)\Delta\pi^g_{t-1} +$$

$$\alpha_3 I(\Delta e_{i,t-1} > \gamma_2)\Delta\pi^g_{t-1} + \alpha_4 I(\Delta e_{i,t-1} \le \gamma_1) y^g_{t-1} + \alpha_5 I(\gamma_1 < \Delta e_{i,t-1} \le \gamma_2) y^g_{t-1} +$$

$$\alpha_6 I(\Delta e_{i,t-1} > \gamma_2) y^g_{t-1} + \alpha_7 I(\Delta e_{i,t-1} \le \gamma_1)\Delta e_{i,t-1} + \alpha_8 I(\gamma_1 < \Delta e_{i,t-1} \le \gamma_2)\Delta e_{i,t-1} +$$

$$\alpha_9 I(\Delta e_{i,t-1} > \gamma_2)\Delta e_{i,t-1} + u_{it} \qquad (5)$$

where $\gamma_1 < \gamma_2$. The estimation result of (5) is as follows:

Threshold estimates	Low regime coefficients	Interim regime coefficients	High regime coefficients	p-value
	$\alpha_1 = 0.047$	$\alpha_2 = 0.221$	$\alpha_3 = 0.002$	
	(0.033)	(0.024)	(0.051)	
	(0.054)	(0.028)	(0.110)	
$\gamma_1 = -1.85$	$\alpha_4 = 0.046$	$\alpha_5 = 0.010$	$\alpha_6 = 0.065$	0.042*
	(0.020)	(0.008)	(0.022)	
$\gamma_2 = 2.60$	(0.031)	(0.005)	(0.027)	0.037**
	$\alpha_7 = -0.056$	$\alpha_8 = -0.001$	$\alpha_9 = -0.003$	
	(0.011)	(0.017)	(0.015)	
	(0.025)	(0.016)	(0.018)	

Table 4. Estimation results for the model in which all variables are regime dependent.
Standard errors and White-corrected standard errors are given in parentheses, respectively.
* p-value for the single threshold model.
** p-value for the double threshold model.

The estimation results of the model in which all variables are regime dependent are consistent with our baseline model in the sense that the asymmetric response to the exchange rate is valid in this model as well. The main difference is that we cannot reject the existence of a double threshold effect possibly due to a very strong response to the inflation gap in the

[29] Threshold values differ for the regressions in which exchange rate movements are taken as deviation of NEER from its moving average and as monthly percentage changes of REER (columns 3 and 4). This is natural since monthly changes of NEER, in absolute value, are generally higher than monthly changes in REER and lower than the deviation of NEER from its moving average.

interim regime. The evidence suggests that whereas depreciations greater than 1.85 percent lead to an increase in the interest rate ($\alpha_7 = -0.056$), appreciations and small depreciations do not have a statistically significant impact on interest rate decisions of central banks with very low coefficients ($\alpha_8 = -0.001, \alpha_9 = -0.003$). Moreover, in the low regime where depreciation is greater than 1.85 percent, central banks seem to be irresponsive to the inflation gap, indicating that their main concern is the exchange rate in the existence of strong depreciation trends. In the interim regime, however, they do not respond to small deviations of the exchange rate but rather respond heavily to the inflation gap. In the high regime where appreciations are greater than 2.60 percent, the inflation gap does not have a statistically significant coefficient, possibly implying that central banks consider that high levels of appreciation in their currency would ease inflationary pressures and prefer to remain irresponsive to the inflation gap.

Is an asymmetric policy stance particular to developing countries?

Thus far we analyzed interest rate responses of IT developing country central banks and remained silent about their advanced counterparts. All the factors that we discussed in the introduction as possible reasons for an asymmetric policy stance in IT regimes are not applicable to advanced countries. Many advanced countries took inflation under control earlier; therefore they had low inflation levels and relatively high credibility when they adopted IT. Besides, supply side factors generally are not as important as in developing countries, as determinants of inflation. Moreover, the monetary transmission mechanism may be more effective in developed countries, all reducing the importance of the exchange rate channel in these countries. Thus, there is no "a priori" reason for advanced countries to adopt such an approach. In this part, we replicate the same analysis for advanced countries in order to see whether there is any difference in their approach to exchange rate movements from that of developing countries[30].

We use the same time period (2002:1-2008:9) in order to compare the results with the developing country case. During this period, there were seven IT advanced countries: Australia, Canada, Iceland, Norway, New Zealand, Sweden and the United Kingdom. Given that inflation targets are relatively stable (around 2-3 percent) in advanced countries, we do not construct an inflation gap variable but rather include inflation directly in the regression model, letting the inflation target be subsumed in country fixed effects α_i.

[30] It would be very interesting to apply the same analysis to a set of non-IT developing countries in order to see whether there is any difference between IT and non-IT countries in their approach to exchange rate movements. Again, there is no a priori reason for non-IT countries to follow an asymmetric policy stance. In fact, there are empirical studies demonstrating that in many countries appreciations are restrained more heavily than depreciations in the last decades. For instance, by covering 179 countries, Levy-Yevati et al. (2013) demonstrate that "fear of appreciation" was prevalent especially in the 2000s. Thus, it is likely that non-IT countries' reactions to exchange rate movements differ from IT countries' reactions given that their main motives while conducting monetary policy are different. However, when we analyzed emerging/developing countries (40 countries were chosen according to their GDP level), we realized that the bulk of non-IT countries in this group adopted some sort of fixed exchange rate regime at least for some period between 2002 and 2008. What is more, the remaining minority also has heavily managed or de facto peg regimes. These countries, seemingly, conduct monetary policy different than the conventional Taylor rule and their fixed/heavily managed exchange rate regime hinders us to replicate a similar analysis on non-IT developing countries.

The data for policy interest rates are taken from the IMF, International Financial Statistics (IFS) except for Iceland for which we used data from the central bank. Exchange rate changes are again calculated as the monthly percentage change of NEER obtained from the BIS data. Data for consumer price inflation and the industrial production index are obtained from the IFS[31]. The output gap is calculated in the same way as explained above. Inflation is taken as the percentage change of CPI at a given month from the same month of the previous year.

Unit root test results indicate the existence of unit root processes for the interest rate and inflation variable as can be seen from Table A.2. Thus, we used their first difference in the regression. The estimated model is given below:

$$\Delta i_{i,t} = \alpha_i + \alpha_1 \Delta\pi_{i,t-1} + \alpha_2 y^g_{i,t-1} + \alpha_3 I\left(\Delta e_{i,t-1} \geq \gamma\right)\Delta e_{i,t-1} + \alpha_4 I\left(\Delta e_{i,t-1} < \gamma\right)\Delta e_{i,t-1} + u_{i,t} \quad (6)$$

where $\Delta i_{i,t}$, is the first difference of policy interest rate, $\Delta\pi_{i,t-1}$ is the first difference of 12 month CPI inflation, $y^g_{i,t-1}$ is the output gap, $\Delta e_{i,t-1}$ is the monthly percentage change of exchange rate, γ is the threshold value to be estimated and $u_{i,t}$ represents the error term. Table 5 summarizes the estimation results:

Threshold estimate	Regime independent variables ($\Delta\pi_{i,t-1},\ y^g_{i,t-1}$)	Regime dependent variable ($\Delta e_{i,t-1}$)	LR test statistic	p-value
$\gamma = 0.41$	$\alpha_1 = 0.076$ (0.021) (0.032) $\alpha_2 = 0.007$ (0.003) (0.003)	$\alpha_3 = 0.024$ (0.010) (0.010) $\alpha_4 = -0.018$ (0.009) (0.016)	7.57 $(9.43)^a$ $(11.92)^b$ $(15.97)^c$	0.165

Table 5. Estimation results for the group of inflation targeting advanced countries.
Standard errors and White-corrected standard errors are given in parentheses, respectively.
a, b, c: 10%, 5%, 1% critical values, respectively.

Estimation results for advanced countries imply that the linearity assumption is not rejected with conventional significance levels[32]. Thus the threshold specification is not the appropriate model in the case of advanced countries and a linear model should be used instead. Thus, we can conclude that the asymmetric response to the exchange rate is not observed in advanced countries. This may be either due to the symmetric response of advanced countries to

[31] We used monthly data for Canada, Iceland, Norway, Sweden and the United Kingdom. Due to unavailability of monthly data for Australia and New Zealand we used quarterly data for these countries and transformed them into monthly frequencies using cubic spline interpolation.

[32] We also used different measures for inflation and exchange rate and check whether the results are sensitive to these changes. First, we calculated inflation as monthly percentage change of seasonally adjusted CPI. Second, instead of nominal effective exchange rate, we used real effective exchange rate data. The new results are again in favor of a linear model with high p-values.

exchange rate movements or to their unresponsiveness to the exchange rate at all[33]. In either case, the evidence suggests that the asymmetric policy stance applies only to IT developing countries possibly due to aforementioned characteristics of these economies.

4. Concluding Remarks

The analysis of interest rate setting decisions supports the argument that IT central banks in developing countries exhibited an asymmetric policy stance favoring appreciation. In this sense, evidence suggests that IT countries are inclined to use the exchange rate to the best of their interests. This practice is in stark contrast with the main tenets of IT and also with official declarations of central banks. Officially, most IT central banks have floating exchange rate regimes. In this vein, our findings suggest that there is a substantial difference between policy implementation and what theory suggests. The way IT central banks in developing countries reach their announced targets may be substantially different than what they claim they are doing. Thus, we can conclude that toleration of currency appreciation appears to be a characteristic feature and an essential component of IT regimes in developing countries, an important issue, and, apart from the small literature cited above, largely neglected thus far in the literature.

Until disrupted by the global crisis, there existed a steady appreciation trend in many IT developing countries. This was mainly the result of ever increasing capital inflows. An asymmetric policy stance required overlooking this trend. In turn, large risks accumulated in these countries in the form of excessive credit growth, overly appreciated currencies and increasing current account deficits. In this vein, Kaminsky et al. (1998) find the level of real exchange rate as an important indicator of currency crises. Similarly, Frenkel and Taylor (2009) emphasize that overappreciation may create dangers by destabilizing capital flows. Kumhof (2000), on the other hand, asserts that the endogenous policy response of a central bank in the IT regime summarized in footnote 7 may lead to excessive deficits in the current account which in turn may trigger the collapse of the currency.

Developing countries largely neglected these dangers when inflows were steady. However, the eruption of the global crisis put an end to the passive stance with respect to inflows, paving the way for a more complex monetary policy framework to deal with undesired consequences of financial flows in the new era. In the new period, macroprudential measures gained importance by which central banks adopted a more careful approach about detrimental impacts of capital flows on their countries. Accordingly, ensuring financial stability emerged as an additional policy objective along with price stability, a development which is also sometimes referred to as the emergence of "enhanced IT". Thus, it is possible that increasing concerns over financial stability (possibly surpassing concerns over inflation even in the existence of IT) discarded the asymmetric policy stance in the new era. However, some still

[33] Since it is not directly related with our purposes, we do not embark on presenting the results of estimation of linear monetary policy reaction functions for advanced countries. However, a basic analysis of the monetary policy reaction function through fixed effect estimation leads to statistically insignificant coefficients of exchange rate. The results are not reported here but are available from the authors upon request.

argue that IT is still the unique option as a monetary policy regime[34] and central banks should return to the original IT framework. Our study raises concerns over the associated dangers of such a return for developing countries. We call for a more careful approach for the implementation of monetary policy by evaluating the costs of the previous form of IT.

In this paper, we focused on the interest rate decisions of central banks. This seems indispensable given that the short term interest rate is the main policy tool of central banks under IT regimes. However, the policy rate is not the sole instrument central banks have at their disposal for responding to exchange rate movements. They can also intervene in the foreign exchange market in order to affect the level of the exchange rate. Although they officially announce that their motivations behind intervention are related to hindering excessive fluctuations in the exchange rate, our findings suggest that their interventions in the foreign exchange market may be asymmetric as well. Such an analysis is beyond the scope of this paper but is a potential area for further research.

Another limitation of this study is that our analysis focuses on the period until the eruption of the global economic crisis. It would be interesting to compare the responses to exchange rate movements during the pre-crisis and post-crisis periods. The heavy emphasis on financial stability in the post-crisis period might have undermined the asymmetric policy stance. Another potential research area is to analyze the case of non-IT developing countries. Due to the prevalence of fixed/heavily managed exchange rate regimes in these countries, an econometric analysis focusing on the interest rate policies of the central banks in these countries would not be a useful exercise. Therefore, one should utilize different methods in order to compare responses of IT and non-IT countries to exchange rate movements.

[34] See, for instance, a recent book to which some prominent proponents of IT contribute: Reichlind and Baldwin (2013).

Appendix

	Test method	Test statistic./p-value $\Delta e_{i,t}$	$y_{i,t}^{g}$	$\pi_{i,t}^{g}$	$\Delta\pi_{i,t}^{g}$	$i_{i,t}$	$\Delta i_{i,t}$
Individual intercept	Levin, Lin and Chu	-19.69/0.00	-3.85/0.00	-034/0.37	-17.98/0.00	-1.54/0.06	-13.73/0.00
	Im, Pesaran and Shin	-18.79/0.00	-15.60/0.00	-1.58/0.06	-16.96/0.00	-0.83/0.20	-14.96/0.00
	ADF – Fischer Chi Square	314.59/0.00	200.07/0.00	45.77/0.00	286.76/0.00	35.99/0.06	235.21/0.00
Individual intercept and trend	Levin, Lin and Chu	-22.89/0.00	-2.82/0.00	-1.72/0.04	-18.38/0.00	-2.65/0.00	-16.51/0.00
	Breitung	-7.54/0.00	-1.75/0.04	-1.30/0.10	-11.66/0.00	2.20/0.99	-9.03/0.00
	Im, Pesaran and Shin	-20.32/0.00	-13.64/0.00	-1.33/0.09	-16.26/0.00	-0.69/0.25	-15.85/0.00
	ADF – Fischer Chi Square	323.97/0.00	178.39/0.00	38.32/0.03	241.20/0.00	34.56/0.08	232.74/0.00

Table A.1. Panel unit root test results for developing countries.
Null hypothesis for Levin, Lin and Chu test & Breitung test: Common unit root process.
Null hypothesis for Im, Pesaran and Shin test & ADF-Fischer Chi Square test: Individual unit root process.

	Test method	Test statistic/p-value $\Delta e_{i,t}$	$y_{i,t}^{g}$	$\pi_{i,t}$	$\Delta\pi_{i,t}$	$i_{i,t}$	$\Delta i_{i,t}$
Individual intercept	Levin, Lin and Chu	-15.61/0.00	3.58/0.99	5.49/1.00	-1.82/0.03	0.19/0.58	-10.32/0.00
	Im, Pesaran and Shin	-14.94/0.00	-8.93/0.00	1.32/0.90	-11.50/0.00	1.85/0.97	-11.63/0.00
	ADF – Fischer Chi Square	192.28/0.00	110.24/0.00	13.23/0.51	145.79/0.00	6.39/0.96	139.29/0.00
Individual intercept and trend	Levin, Lin and Chu	-16.21/0.00	5.08/1.00	4.95/1.00	-0.55/0.29	-0.65/0.26	-13.15/0.00
	Breitung	-4.88/0.00	-1.26/0.10	-0.51/0.31	-3.84/0.00	3.94/1.00	-2.45/0.01
	Im, Pesaran and Shin	-14.62/0.00	-7.47/0.00	0.26/0.60	-10.57/0.00	-0.16/0.44	-13.22/0.00
	ADF – Fischer Chi Square	177.74/0.00	88.86/0.00	15.55/0.34	126.40/0.00	22.33/0.07	153.35/0.00

Table A.2. Panel unit root test results for advanced countries.
Null hypothesis for Levin, Lin and Chu test & Breitung test: Common unit root process.
Null hypothesis for Im, Pesaran and Shin test & ADF-Fischer Chi Square test: Individual unit root process.

Calculation of Monthly Inflation Targets

The method to calculate the inflation target of a central bank at a given month is as follows: Consider we are at the beginning of year t. Then, monthly inflation targets $(\pi^*_{t,i})$ for this year are defined as:

$$\pi^*_{t,i} = \pi^*_{t,i-1} - (\pi_{t-1} - \pi^*_t)/12$$

with

$$\pi^*_{t,1} = \pi_{t-1} - (\pi_{t-1} - \pi^*_t)/12$$

where $i = 2,3,\dots,12$ stands for the months of year t; π_{t-1} represents realized inflation at year $t-1$; and π^*_t gives the inflation target of the central bank for the year t.
Source: Benlialper and Cömert (2016b).

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