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 a different policy stance with respect to depreciation and appreciation. We specifically demonstrate that during the period under investigation (2002-2008), central banks in developing countries which implement IT have tolerated appreciation but fought against depreciation in order to hit their inflation targets. In order to support this argument, we analyze central banks' interest rate decisions by estimating a nonlinear monetary policy reaction function using a panel threshold model. Evidence suggests that whereas central banks respond to depreciation pressures beyond some threshold, they remain inactive to appreciation.

Key words: Inflation Targeting, Central Banking, Developing Countries, Exchange Rates

JEL Code: E52, E58, E31, F31

1. Introduction

In years preceding the global crisis of 2008, there had emerged a new consensus on the appropriate framework for monetary policy. According to the 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, 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 could be dealt with appropriate monetary policy. 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 were assumed to share similar characteristics. Hence, developing and advanced countries were expected to tackle with 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 IT framework. If the major sources of inflation are related with supply side factors which are generally beyond what monetary policy can 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 depending upon external conditions such as international commodity prices or exchange rate 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 central bank can opt to do nothing if the failure in achieving the target is related with external shocks. However, if these shocks appear too frequently as in the case of many developing countries possibly leading to "regular" misses, the main tenet of IT, "credibility" of the central bank, may suffer to a great extent. In that case, an IT central bank may have to resort to other measures in order to hit the targets and preserve its credibility. Given the importance of exchange rate in shaping inflation, then, IT central banks in developing countries may find it useful to use exchange rate implicitly as an additional policy tool.

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

[2] According to Anwar and Islam (2011), main sources of inflation in developing countries are sudden supply shocks rather than unsuccessful macroeconomic policy. In least developed countries, the correlation between inflation and food prices are found 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 exchange rate is found to contribute significantly to inflation in many countries. A similar argument is made for 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 with exchange rate changes and misses of inflation targets (Ho and McCauley, 2003; Roger and Stone, 2005), highlighting the importance of exchange rate in determining inflation.

During the period before 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. Formally, IT central banks declare that they have floating exchange rate regimes, though they reserve the right to intervene in case of excessive fluctuations. The main finding of the paper is that appreciation trend is related with a deliberate policy stance of central banks in developing countries which used exchange rate to hit their targets. More specifically, evidence suggests that they adopted an asymmetric policy stance with respect to exchange rate tolerating appreciation and fighting against depreciation. Although the extent to which this policy stance explains the appreciation trend remains unclear, it might well have contributed to it.

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

Moreover, Table 1 also indicates that success/failure of monetary policy and exchange rate may be related 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 can be quite important if the focus is on inflation. It also endows monetary authority with a powerful tool, exchange rate in order to hit inflation targets.

Developing countries generally witnessed higher inflation rates compared to their advanced counterparts prior to their adoption of IT. Indeed, many countries implemented IT as they believed it can contribute to the disinflationary process that they are already undergoing. In this sense, an asymmetric stance with respect to exchange rate can also be preferable for the

[3] We should also note that these developments occurred in the background of moderate changes in commodity prices during "Great Moderation" which also contributes to the phenomenon called "global disinflation" by some authors. In the absence of such disinflationary trend, we would expect a more intense use of exchange rate by the IT central banks.

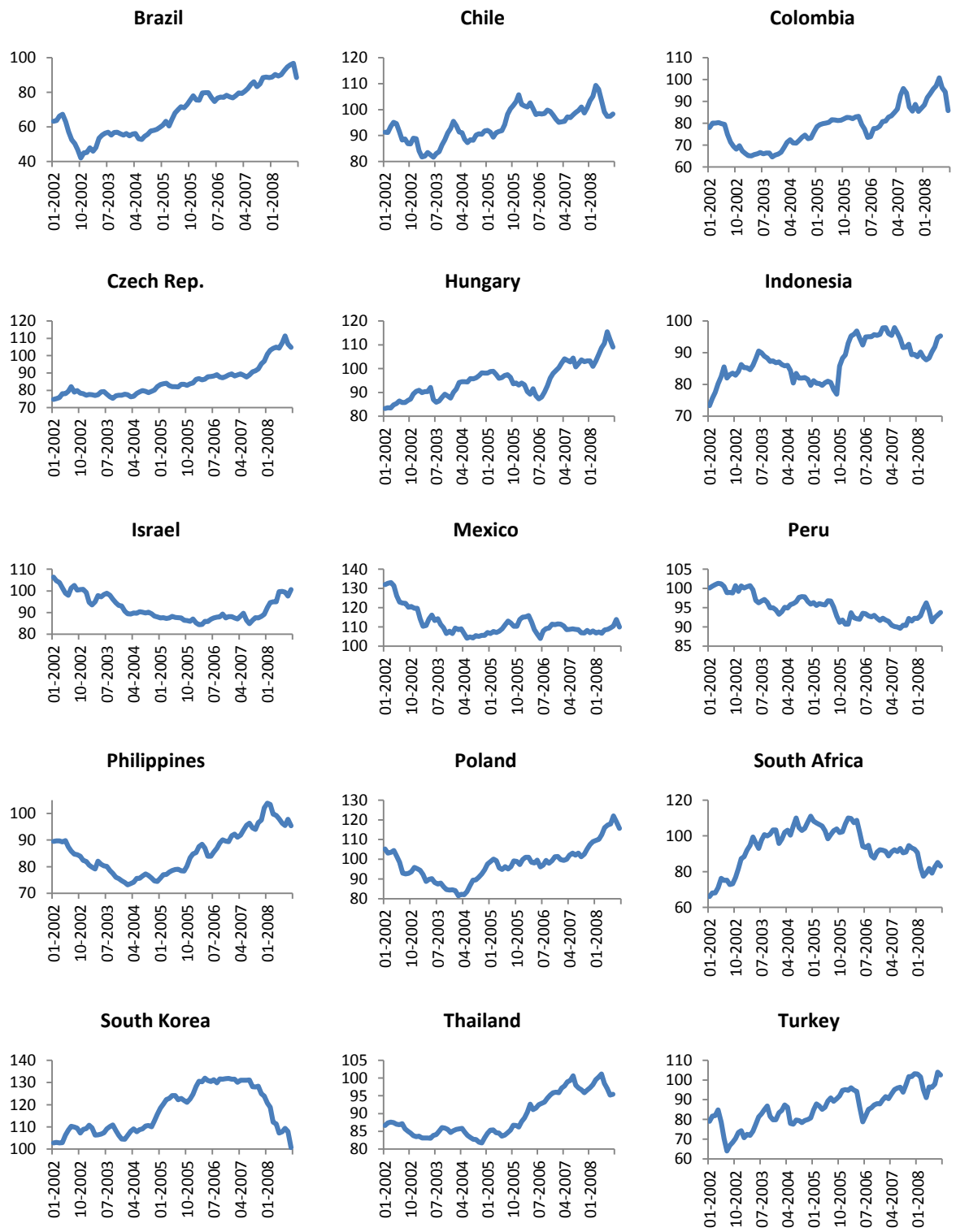

Figure 1. Real effective exchange rates in inflation targeting developing countries (2002-2008). Source: Bank for International Settlements, 2010=100.

		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[4].

[4] 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 central

IT central banks. 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. Hence, they may remain reluctant in case of undershoots since this may change expectations over future inflation and helps to achieve lower inflation targets in the future. Moreover, given that lower bounds of the target are generally higher, undershoot of the target does not lead to deflation, partially explaining the irresponsiveness of monetary authorities. This scenario, then, also explains the lax stance with respect to undershoots and tight responses in case of overshoots. This again entails an asymmetric exchange rate policy for 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 monetary transmission mechanism, utilization of exchange rate as an implicit policy tool become imperative for the developing country central banks in order to curb inflation and meet the targets.[5] [6]

In order to test our main hypothesis, namely that IT central banks in developing countries responded exchange rate changes asymmetrically[7], we analyze central banks' interest rate decisions by estimating a nonlinear monetary policy reaction function using a panel threshold model. Evidence suggests that whereas central banks respond to depreciation pressures beyond some threshold, they remain inactive 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.

There is a vast literature on asymmetric responses of various central banks to changes in inflation and output, however, asymmetric stance with regards to 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 nature using econometric techniques (Benlialper and Cömert, 2015b; Galindo and Ros, 2008; Libanio,

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

[5] One of the most striking official declaration recognizing the inability of conventional monetary policy implementation in containing inflation and underlining the possible role of 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).

[6] There are also other factors which can partially explain 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, typical 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.

[7] It is worth to mention that what we refer to asymmetric policy stance does not require central bank 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 when the trend reversed they responded to depreciation pressures. Hence, asymmetric policy response is likely to emanate from the difference in degree of tolerance of central bank with respect to direction of the exchange rate.

2010)[8]. 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 analyze the monetary policy reaction function of several IT developing countries in order to investigate whether they respond asymmetrically to the exchange rate. With the same aim, the third section focuses on the determinants of exchange rate intervention in these countries. The last section concludes.

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

Since Taylor (1993) proposed a simple monetary policy rule designed for 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 have become widespread in empirical studies. Second, many studies incorporated exchange rate in monetary policy reaction function of central bank. Lastly, there has emerged a 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 exchange rate.

The inclusion of exchange rates in 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 central bank's policy decisions if it takes into account the impact of changes in exchange rate both on output and inflation when setting interest rates (Taylor, 2001). Thus, there is no need for including exchange rates directly in the monetary policy rule. This is the standard mainstream open economy IT approach to exchange rate in advanced countries which is called as "Plain Vanilla Inflation Targeting" by Stone et. al (2009). On the other hand, some other authors suggest that 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 exchange rate is a country-specific issue and should be analyzed empirically for each case (Edwards, 2006). In this vein, Benlialper and Cömert (2015b) put forward the distinguished characteristics of developing countries and

[8] We should also mention that there are studies validating the 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 place 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 forced to exhibit an asymmetric policy due to various reasons discussed above.

count mainly three reasons why IT central banks are likely to include exchange rate explicitly in their reaction functions especially in developing countries[9].

The first reason is related with the need for preserving the credibility of the IT regime. As some empirical work documents, exchange rate is an important determinant of inflation in developing countries (Mohanty and Klau, 2001; Benlialper and Cömert, 2015b). 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 the exchange rate movements affect inflation (through import prices) works faster than conventional monetary policy channel (Svensson, 1999). Thus, in principle, central banks may 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 aggregate demand channel. Svensson (2000) suggests that strict IT may require intense use of 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 focused on keeping inflation as close as possible to their inflation target in shorter horizons rather than targeting inflation in longer horizons requiring an intense use of the direct exchange rate channel.

Lastly, the argument for exclusion of exchange rate in monetary policy rule depends on an implicit assumption about the effectiveness of monetary policy. However, there are constraints on the effectiveness of monetary policy in developing countries due to weaknesses in monetary transmission mechanism[10]. Thus, relying on aggregate demand channel to control inflation may prove inadequate in case of developing countries. Given the importance of exchange rate as a source of inflation, then, central banks in developing countries may resort to exchange rate

[9] These reasons are related with the importance of exchange rate in an IT framework. However, developing countries may need to keep a watchful eye on exchange rate beyond inflation concerns. Most notably, exchange rate is crucial for competitiveness and ensuring financial stability since dramatic changes in exchange rate may trigger bank failures especially in developing countries. In this sense, the approach of developing countries and advanced countries to IT should differ for various reasons (Ho and McCauley, 2003). In other words, central banks may respond to exchange rate changes not only for inflation related concerns (fear of floating). This may entail the inclusion of exchange rate into the loss function of the central bank. However, in this study we mainly focus on concerns regarding inflation and do not embark on developing a theoretical model in which exchange rate is present in the loss function.

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

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 a considerable amount of reason to include exchange rate directly in their policy rules. However, as Edwards (2006) emphasizes, this claim should be tested empirically. In fact, many studies verify the existence of exchange rate in monetary policy rule (both for IT and non-IT countries)[11]. Our estimation results also show that exchange rate concerns are valid in monetary policy rule as we find that exchange rate is a statistically significant determinant of changes in policy interest rate.

The existing literature including 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 an enormous literature on asymmetric behavior of central banks with respect to inflation and output gap. Many studies find that central bank responds asymmetrically either to inflation or output gap. More specifically, empirical evidence suggests that central banks respond more strongly to recessions than to expansions[12]. In a similar way, the response to positive inflation gaps is found higher compared to negative inflation gaps revealing inflation avoidance of IT central banks[13] [14]. In this study we will benefit from the literature on nonlinear policy rules and extend it to incorporate nonlinear responses to exchange rate. In the following part, we present our model and discuss its basic properties.

The model

Our model for monetary policy reaction which will be used for empirical purposes is fairly standard in the literature. We assume that central bank moves policy rates in response to inflation gap, output gap and changes in exchange rate. Ball (1999) and Aizenman et. al (2011) derive optimal policy response in open economies and show that optimal rule includes exchange rate[15]. We follow this approach and construct the model for individual country in the following way:

$$i_t = \propto_0 + \propto_1 i_{t-1} + \propto_1 \pi_t^g + \propto_2 y_t^g + \propto_3 \Delta e_t \qquad (1)$$

[11] Björnland and Halvorsen (2010) find that four of six advanced countries in their sample respond to exchange rate movements. 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. Ho and McCauley (2003) contend that developing countries are likely to respond to exchange rate in an IT framework. Aizenman et. al (2011) find that policy interest rates respond significantly to exchange rate variations in IT developing countries.

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

[13] Martin and Milas (2004), Cukierman and Mustacelli (2008), Sznajderska (2014), Kazanas and Tzavalis (2009), Castro (2011), Bunzel and and Enders (2010).

[14] 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 inflation gap (output gap) is asymmetric contingent upon the state of the output gap (inflation gap) (Kazanas and Tzavalis, 2009; Castro, 2011; Bec et. al, 2002).

[15] In Ball (1999) optimal policy rule requires the use of both interest rate and exchange rate as an instrument but it is straightforward to change the equation so that exchange rate is in the right of the equation implying that central bank adjust interest rates in response to exchange rates as Ball (2000) also mentions.

where i_t (i_{t-1}) represents policy rate at time t ($t-1$)[16], 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 with those in the literature. First, inflation gap is generally defined as the gap between observed inflation and inflation target of the central bank. Most of the empirical work focusing on monetary policy rules in IT countries assumes that inflation target is constant over time. Hence while estimating the policy rule they take inflation as the explanatory variable instead of a measure of inflation gap by arguing that constant inflation target is subsumed in the intercept (Aizenman et. al, 2011, Hammermann, 2008). However, in case of developing countries where inflation target changes significantly (especially for countries which are in disinflationary process), this approach may be misleading[17]. In IT regimes, it is the deviation of inflation from the target not the inflation level itself that is responded by the central bank. Thus, instead of taking targeted inflation as time invariant, we construct inflation gap variable as follows[18]:

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

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

The second important characteristic of the policy rule above is that exchange rate enters the monetary policy rule only as percentage change instead of levels or deviation from equilibrium exchange rate as in Taylor (2001). Hence, we assume that central banks respond to exchange rate mainly for inflationary concerns (at least when setting interest rates) and that they do not have a specific target for exchange rate consistent with their statements. Accordingly, in the estimation we use nominal exchange rates as it reflects inflationary concerns more directly whereas real exchange rates are used for robustness check.

The model in (1) is linear. The linearity of monetary policy rule ensues either from the assumption of a quadratic loss function of central bank or from a linear system describing the economic structure. However, there are serious counter studies rejecting a linear Taylor rule[19]. In this regard, in order to detect possible asymmetries in the reaction function, we transform the model in such a way that central bank may change its attitude to exchange rate beyond some threshold. In the theoretical literature, it is well established that if central bank has asymmetric preferences with respect to output gap or inflation, then optimal monetary policy rule is nonlinear. In this sense, our study is similar to the threshold models of Bec. et al (2002) and

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

[17] As Table 1 shows, targets are adjusted frequently in some countries.

[18] Some studies take inflation gap variable as the explanatory variable, however they take 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.

[19] 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.

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 also into account that we apply panel data techniques, we have the following panel threshold model:

$$i_{i,t} = \propto_i + \propto_1 i_{i,t-1} + \propto_2 \pi_{i,t}^g + \propto_3 y_{i,t}^g + \propto_4 I(\Delta e_{i,t} \geq \gamma)\Delta e_{i,t} + \propto_5 I(\Delta e_{i,t} < \gamma)\Delta e_{i,t} \quad (3)$$

in which I is the indicator function taking value 1 if the statement is true and 0 otherwise, $\propto_{i0}$ represents country specific fixed effects, $i_{i,t-1}$, $\pi_{i,t}^g$, $y_{i,t}^g$ are regime independent variables and $\Delta e_{i,t}$ is both the regime dependent variable and the threshold variable.

The data

Our sample consists of 12 IT developing countries: Brazil, Chile, Colombia, Czech Republic, Hungary, Israel, Mexico, Peru, Philippines, Poland, South Africa and Turkey. The sample is chosen on the basis of their adoption dates of IT in the sense that all countries in the sample were implementing IT during the whole period 2002:1-2008:9[20]. The choice of the time period reflects our desire to analyze a specific era in the world economy which was usually called as "great moderation" characterized by low inflation levels, high economic growth and relative financial stability in many countries. 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), 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 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. Moreover, monetary policy framework of developing countries has changed considerably after the crisis. Though, some of them call their framework as "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[21]. Hence, in the new period, developing country central banks have kept a watchful eye on exchange rate, the stability of which is crucial for ensuring financial stability. Accordingly, it is likely that their policy responses to exchange rate extended beyond inflation

[20] 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 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 with that of full-fledged IT. Moreover, some countries which were implementing IT in this period were excluded from our dataset. Korea and Thailand were excluded because they were taking core inflation as the target variable[20]. Core inflation is relatively more stable and less affected from external developments such as exchange rate and commodity price changes compared to headline inflation. Thus, it is a more controllable measure of inflation. We also exclude Indonesia which started implementing IT implicitly in 2000 since this country used base money as the monetary policy instrument which is ultimately replaced with "BI rate" as of 2005.

[21] Interested reader is referred to Hahm et. al (2011), Moreno (2011), Benlialper and Cömert (2015a), 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 exchange rate in the new monetary policy framework in developing countries in the post crisis period.

concerns and incorporated financial stability concerns. Thus, the arguments for asymmetric monetary policy stance with respect to exchange rate are likely to be undermined in the new era.

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 estimation. The dataset starts at 2002:1 and ends at 2008: 9 giving us 80 observations after first lags are excluded. Inflation data (consumer price inflation) is obtained from central banks or national statistical institutions. The measure for inflation gap is defined as in equation (2). The inflation targets for each country in each year is taken from central banks' websites, their annual reports and numerous papers analyzing IT experience of developing countries. In case where inflation target is a range rather than a point, we have taken the average of lower and upper bound of the range as the associated target.

We use nominal effective exchange rate data of BIS for the exchange rate. Interest rates are 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 official policy rates of central banks[22]. In constructing the monthly data, we implemented the following process. If the decision over 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 monthly industrial production index released by national statistical institutes[23]. Then, output gap is calculated as the percentage deviation of seasonally adjusted monthly industrial production index from its trend value which is calculated by Hodrick-Prescott filter.

3. Estimation results

Before presenting estimation results, we first analyze whether any of the variables have a unit root process. We use four most popular panel unit root tests and present the test results in the Appendix, Table A.1. According to the results, interest rate and inflation gap is likely to exhibit a unit root process. Hence, we take the first difference of both variables. Moreover, we assume that interest rate responds to lagged values of explanatory variables[24]. Then, we estimate the following panel threshold model:

[22] In Mexico, 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 bank funding rate as a proxy to policy rate for the period before 2008. Robustness check also shows that excluding Mexico from the dataset does not have a considerable impact on the results.

[23] For Czech Rep., Hungary and Poland we use monthly manufacturing production index available from Eurostat; for Mexico we use OECD data. We were unable to find monthly industrial production data for 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.

[24] The reason follows straightforwardly from our construction of monthly policy interest rate variable. If the change occurs in the first (second) half of the month, it is quite likely that central bank is responding to conditions occurred in the previous (current) month. However, we also checked for the case where explanatory variables enter into the equation without lag. The results will be summarized when we give robustness check results.

$$\Delta i_{i,t} = \propto_i + \propto_1 \Delta\pi^g_{i,t-1} + \propto_2 y^g_{i,t-1} + \propto_3 \left(\Delta e_{i,t-1} \geq \gamma\right)\Delta e_{i,t-1} + \propto_4 I\left(\Delta e_{i,t-1} < \gamma\right)\Delta e_{i,t-1} \quad (4)$$

The above model suggests that, change in policy interest rates are explained by the level of output gap, change in inflation gap and change in exchange rate. However, interest rate changes respond to exchange rate nonlinearly. For movements smaller than some threshold γ, the coefficient for the response to exchange rate is $\propto_3$; whereas for greater values it is $\propto_4$. The estimated model in (4) is the baseline model; however we also test for the case where 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 robustness check.

In the estimation process of (4), following Bunzel and Enders (2010) we use Bruce Hansen's methodology for estimation and testing the nonlinearity assumption. However, since our data has a panel nature, we use the estimation process suggested by Hansen (1999). Following the steps described in Hansen (1999: 348-349), individual effects $\propto_i$ are eliminated and for any given threshold γ, estimated values of slope coefficients $(\propto_1, \propto_2, \propto_3, \propto_4)$ are found by OLS. 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 threshold value in order to leave enough observation in each regime. Accordingly, we take trimming percentage as 0.1 and check other values: 0.15 and 0.2 as part of robustness check. In order to test whether our threshold specification is correct, we use bootstrap method of Hansen (1996) since under the null hypothesis of no threshold, γ is not identified, preventing the use of standard F-test. Thus, we bootstrapped the F-statistic using 1000 replications and then calculate the bootstrap estimate of the p-value for the sample value of the F-statistic. We also check for the presence of double threshold effect. In all specifications including robustness check results, the results do not support double threshold effect with very high p-values. Thus, they are not reported here but are available upon request.

The estimation result of (4) is as follows:

Threshold estimate	Regime independent variables $(\Delta\pi^g_{i,t-1},\ y^g_{i,t-1})$	Regime dependent variable $(\Delta e_{i,t-1})$	F-statistic	p-value
$\gamma = -3.13$	$\propto_1 = 0.145$ (0.017)* $\propto_2 = 0.017$ (0.006)*	$\propto_3 = -0.008$ (0.010)* $\propto_4 = -0.059$ (0.010)*	9.94 (7.14)** (10.36)** (16.90)**	0.055

Table 2. Estimation results for the baseline model.
* OLS standard errors
** 10%, 5%, 1% critical values, respectively

The results indicate that central banks respond to depreciations greater than 3.13% whereas they remain quite irresponsive to any other exchange rate movement including both appreciations

and small depreciations given that the low regime coefficient is very close to zero. On the other hand, results also reveal that whereas central banks remain relatively irresponsive to output gap, they strongly react to inflation as evidenced by the high coefficient of the inflation gap implying that the major consideration of central banks is inflation in IT developing countries. Test results also show that threshold effect is significant in 90% confidence level validating the nonlinear structure of the model.

Overall, estimation results clearly demonstrate the depreciation avoidance of IT central banks in developing countries. Hence, the policy stance with respect to exchange rate is asymmetric in the sense that central banks tolerate appreciation and remain irresponsive 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 check

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 inflation target was assumed to be constant for each month of the same year. By allowing inflation target to change for each month, we assume that 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 used equation (2) in order to construct 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 inflation gap is stationary. Hence, instead of taking first difference of inflation gap, we let it enter into equation (4) in levels. The results of this change are reported in column 2.

We estimated model (4) with explanatory variables entering into the equation with contemporaneous values instead of first lags as also mentioned in footnote 24. We also implemented the original estimation procedure using different trimming percentages. Though we document only for the case where trimming percentage is taken as 0.2, the results with 0.15 is quite similar. The results of these specifications are given in column 3 and 4 of Table 3, respectively.

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, we used real effective exchange rate data (source: BIS) in the estimation process. Then, instead of using the month to month percentage change, change in exchange rate is defined as the deviation of exchange rate at current period from its moving average over 6 months. Mathematically, the new variable for each country is:

$$\Delta e_t = e_t - \frac{1}{6}\sum_{i=t-6}^{t-1} e_i \qquad (5)$$

The results using new exchange rate variables are given in columns 5 and 6. Moreover, we re-estimated model (4) without Israel and Mexico given considerations discussed above. The results with 10 countries are available in column 7 of Table 3. Lastly, we estimated model (3) given that interest rate may not exhibit unit root process as some tests suggest. The results of this change are given in column 8.

	1	2	3	4	5	6	7	8
γ	-3.13	-3.14	-3.14	-2.13	-3.33	-3.31	-3.13	-2.13
$\propto_1$	0.090 (0.018)	-0.012 (0.006)	0.189 (0.017)	0.145 (0.017)	0.147 (0.018)	0.180 (0.017)	0.137 (0.018)	0.964 (0.004)
$\propto_2$	0.021 (0.007)	0.021 (0.007)	0.013 (0.006)	0.017 (0.007)	0.018 (0.007)	0.012 (0.06)	0.020 (0.007)	0.100 (0.018)
$\propto_3$	-0.008 (0.010)	-0.005 (0.011)	0.005 (0.010)	-0.006 (0.011)	-0.008 (0.010)	0.001 (0.006)	0.000 (0.011)	-0.016 (0.006)
$\propto_4$	-0.058 (0.010)	-0.062 (0.011)	-0.046 (0.010)	-0.055 (0.010)	-0.056 (0.011)	-0.038 (0.004)	-0.053 (0.010)	0.004 (0.011)
$\propto_5$	-	-	-	-	-	-	-	-0.067 (0.010)
F-stat	9.38	11.79	11.58	8.00	8.64	20.99	10.29	18.41
p-value	0.045	0.019	0.058	0.062	0.077	0.005	0.042	0.005

Table 3. Estimation results for different specifications.

The results reveal that the main conclusion we draw from the baseline model is preserved under different specifications. In all regressions, asymmetric response to exchange rate is clear with threshold varying from -2.13 to -3.14. Moreover, in almost all models central banks respond to inflation gap whereas the coefficient of output gap is close to zero. All of the nonlinearity test results indicate the existence of nonlinearity with 90% confidence level (95% for some specifications).

4. Concluding Remarks

The analysis of interest rate setting decisions supports our hypothesis that IT central banks in developing countries exhibited an asymmetric policy stance favoring appreciation. In this sense, evidence supports our claim that IT countries are forced to use exchange rate to the best of their interests[25]. In other words, what conventional monetary policy cannot achieve is left to currency appreciation. This 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 no pure IT in case of developing countries

[25] There may be differences in the degree of asymmetry in individual countries and the asymmetry may even not exist in some countries but the panel data results draw us a general picture.

and there is a substantial difference between what theory suggests and policy implementation. The way IT central banks in developing countries reach their announced targets is 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 largely neglected thus far in the literature.

In light of our findings, we discuss the associated policy implications in this part. First, until disrupted by the global crisis of 2008-09, there existed a steady appreciation trend in many IT developing countries. This was mainly the result of ever increasing capital inflows. Asymmetric policy stance required overlooking this trend. In turn, large risks accumulated in these countries in form of excessive credit growth, overly appreciated currency and increasing current account deficit[26]. 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 macro-prudential measures to deal with undesired consequences of financial flows in the new era.

The second cost of such policy stance is related with its tendency to suppress aggregate demand. The asymmetric policy not only restrains domestic consumption and investment, but also dampens external demand through appreciation. Thus, we can claim that IT lacks a development oriented approach to exchange rate. It puts too much emphasis on inflation and neglects output as also evidenced by estimated coefficients of output gap in regressions. IT was once praised for its positive impact on economic growth by providing price stability. However, these impacts have not materialized at best, and IT might even have made it worse by suppressing domestic demand and triggering currency appreciation.

In the aftermath of the crisis developing countries introduced more complex monetary policy regimes and IT lost its attraction in many countries. 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 argue that IT is still the unique option as a monetary policy regime[27]. Our study raises concerns over the associated dangers of such a return. We call for a more development oriented and careful approach for implementation of monetary policy by evaluating the costs of the previous form of IT.

[26] Kaminsky et. al (1998) find the level 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 central bank in the IT regime summarized in footnote 6 may lead to excessive deficits in current account which in turn may trigger the collapse of the currency.

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

Appendix

	Test method	Stat./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

Calculation of Monthly Inflation Targets

The method to calculate inflation target of a central bank at a given month is as follows: Consider we are at the beginning of year t. First, the difference between the inflation target for the year t (π_t^*) and the actual end year inflation of the year $t-1$ (π_{t-1}) is divided by 12. Then, monthly inflation targets are defined as:

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

with

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

Source: Benlialper and Cömert (2015b)

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