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Exchange Rate Pass-through Effects and Inflation Targeting in Emerging Economies: What is the Relationship?*

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Abstract

Several studies have shown that over the past ten years the pass-through effect from currency depreciation into domestic inflation has been decreasing in emerging economies that adopted Inflation Targeting (IT) during the mid and late nineties. Therefore the nominal exchange rate effect on domestic inflation is becoming less of an issue for these countries. The literature has offered different explanations for these declines but so far they have not been directly related to the adoption of IT. This paper shows that lower pass-through effects can also be the result of the implementation of an IT regime and argues, contrary to previous studies, that the effects of the nominal exchange rate on inflation are still a relevant issue for emerging IT countries. The reason for this is that the empirical evidence offered for the lower pass-through misses the nature of the relationship between inflation and the nominal exchange rate under IT.

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1. Introduction

Over the past few years several studies have undertaken the task of studying, empirically and theoretically, the exchange rate pass-through effect in emerging economies[1]. This effect is defined as the share of domestic currency depreciation, accumulated over a certain period of time, which translates into domestic inflation[2]. Most of the emerging countries considered in empirical studies abandoned a Crawling Peg (CP) or a fixed exchange rate regime and either adopted a flexible exchange rate regime or Inflation Targeting (IT) during the periods for which the exchange rate pass-through effect into domestic inflation is analyzed. Although this regime switch is acknowledged in previous studies, most of them offer several explanations for the declining pass-through effect unrelated to the adoption of IT. Furthermore, some authors even argue that given the lower pass-through effects observed recently in emerging economies where IT was adopted, domestic currency depreciation effects on domestic inflation may no longer be an issue for countries that have or want to adopt IT[3]. The analysis presented in this study argues that this is not necessarily the case and that the evidence offered for the lower pass-through misses the nature of the relationship between inflation and the nominal exchange rate under IT.

Evidence for lower pass-through effects include lower correlation coefficients between inflation and domestic currency depreciation, as well as lower estimated coefficients for accumulated depreciation rates in regressions where either the inflation or the interest rates are the dependent variables. The interpretations for the declining pass-through effect include those by Agenor (2002), Leiderman and Bar-Or (2000), Mishkin and Savastano (2001), and Schmidt – Hebbel and Werner (2002). Using different methodologies and arguments they all conclude that the pass-through effect depends on the credibility of the IT regime and therefore it is likely to decline overtime as the IT commitment becomes clearer. Baqueiro, Diaz de Leon, and Torres (2003), Choudhri and Hakura (2001), Goldfajn and Ribeiro da Costa Werlang (2000), and Taylor (2000) relate the exchange rate pass-through to the inflation environment. They argue and show empirically that when the inflation rate is low, individuals' expectations are more likely to be in line with the authorities target and therefore will be less influenced by short term exchange rate movements. Garcia and Restrepo (2001) show that for the past decade the decrease in the pass-through effect for Chile was related to negative output gaps that compensated the inflationary effects of the currency depreciation. Campa and Goldberg (2002) in their study for 25 OECD countries argue that the most important determinants of the changes in the pass-through over time are microeconomic and relate to the industry composition of a country's import bundle. They show that pass-through elasticities, into aggregate import prices, for manufacturing products and food are generally partial, while for energy and raw material imports they are closer to one.

None of these explanations or arguments relates the decreasing pass-through effect directly to the abandonment of a CP or a fixed exchange rate regime and the adoption of IT. Even though this pattern matches most of the countries included in the studies mentioned above. Gagnon and Ihrig (2004) offer an alternative explanation for the declining pass-through effects observed in developed countries since the 1980's[4]. They show, analytically, that lower pass-through effects can be attributed to increased emphasis on inflation stabilization by many central banks but their empirical results, regarding the relationship between declining pass-through effects and changes in monetary policy, are inconclusive. Following their lead, this study first shows that the decline of the pass-through effect, measured as the share of accumulated depreciation that translates into domestic inflation, is an expected result in emerging countries that implement IT due to "fear of floating" practices that are *justified* under this regime[5]. Therefore it is not the case that the domestic currency depreciation effects on inflation are no longer an issue. In fact, the declining pass-through is the result of the high incidence that domestic currency depreciation would have on inflation if changes in the nominal exchange rate were left unchecked by an IT central bank. Additionally, simulations of the analytical framework are presented and the results show that the predictions of the model match the data. In other words, it is possible to correlate declining pass-through effects with changes in monetary policy. The paper is limited to the analysis of the pass-through effect under the CP and IT regimes, in other words it ignores other important issues like the study of the welfare implications of monetary policy actions observed under each of these regimes.

2. Analytical Framework

The framework presented here corresponds to that of a small open economy where traded and non-traded goods are present. It utilizes a price determination framework similar to that used in Auernheimer and George (2000) and Kumhof (2001) to compare the pass-through effect observed under two monetary regimes, Crawling Peg (CP) and Inflation Targeting (IT)[6]. The overall price index is a combination of the non-traded and traded goods price indices. Specifically its lognormal form is:

$$P_t = \rho P_t^T + (1-\rho) P_t^H \qquad (1)$$

where P_t^T and P_t^H represent the domestic price levels for the traded and non-traded goods, respectively, while ρ denotes the proportion of traded goods[7]. Assuming that the law of one price holds for the traded good, then the foreign price for the traded good, P_t^{T*}, times the nominal exchange rate, E_t, is equal to the domestic price of the traded good, $E_t P_t^{T*} = P_t^T$. Furthermore and without loss of generality the foreign price for the traded good is normalized to one. The resulting expression for the overall price level is the following:

$$P_t = \rho E_t + (1-\rho)P_t^H \tag{1'}$$

Assuming that the non-traded good price responds sluggishly[8], specifically as a function of the expected changes in the nominal exchange rate and the difference between the traded and the non-traded good price levels in the previous period, then the expression for the non-traded good price level is:

$$P_t^H = P_{t-1}^H + (E_t^e - E_{t-1}) + \gamma(E_{t-1} - P_{t-1}^H) \tag{2}$$

where E_t^e denotes the expected nominal exchange rate at period t – 1. Recalling that the real exchange rate is determined by P_t^T / P_t^H and that the price of the traded good is equal to the nominal exchange rate then the last term in equation (2) simply represents the misalignments of the real exchange rate from its equilibrium level and γ determines the rate of adjustment of the non-traded good price level to these misalignments. After substituting the non-traded good price level in expression (1') with expression (2), the overall price level expression can be rewritten as

$$P_t = E_t^e + \rho(E_t - E_t^e) + (1-\rho)(1-\gamma)[P_{t-1}^H - E_{t-1}] \tag{3}$$

If there is no uncertainty, the expected and the realized nominal exchange rate are equal and the overall price level would be determined by the following expression:

$$P_t = E_t + (1-\rho)(1-\gamma)[P_{t-1}^H - E_{t-1}] \qquad (3')$$

Due to recent arguments and findings reported in the literature, the strong assumption that the law of one price holds requires further discussion. This study presents a comparative analysis of the inflationary dynamics, resulting from a sudden and unexpected change of the nominal exchange rate, between two monetary regimes, CP and an IT. Recent work by Corsetti and Pesenti (2002) and Taylor (2000), among others, have shown that pricing behavior of tradable goods (local currency pricing versus producer currency pricing) can respond endogenously to the choice of monetary regimes and adjustments in monetary policy. Corsetti and Pesenti (2002) show that, in equilibrium, exporter pricing behavior will follow the law of one price when exchange rates are highly volatile. Intuitively, firms fully insulate their revenue from exchange rate fluctuations[9]. Therefore, the assumption about the law of one price holding for tradable goods is not completely out of place under IT in emerging economies, where the nominal exchange rate is flexible and volatile. Regarding the crawling peg case, Taylor (2000) argues that in countries characterized by highly volatile monetary regimes, producers will let the price of exports absorb most of the changes in the nominal exchange rate. This scenario matches the reality of most emerging economies over the past ten to fifteen years. The frequent currency crises that materialized during the eighties and nineties, in countries that were implementing crawling pegs or fixed exchange rate regimes, are evidence of the monetary and fiscal instabilities of these emerging economies. Under this circumstances, firms facing high degree of uncertainty regarding the continuation of the fixed exchange rate, would try to shield their revenues from sudden and unexpected exchange rate movements by also following the law of one price.

Additionally, the objective of the paper is to capture the different effects that result purely from changing the monetary policy regime from CP to IT, i.e. maintaining other relevant factors constant. Therefore the law of one price is used as a simplifying assumption. If a local currency pricing framework was used for both regimes, instead of the law of one price, the results are not expected to change dramatically. This is because the firms pricing behavior, given the arguments put forward by Corsetti and Pesenti (2002) and Taylor (2000), would not differ substantially across regimes. The pass-through elasticities from exchange rate movements into traded goods prices would be similar for both regimes.

The simple framework described above for the dynamics of the overall price level can be used to analyze the pass-through effect from exchange rate movements into domestic inflation for the two monetary regimes that are considered in this study, CP and IT[10]. This section discusses the results for a simple non-stochastic framework, but section 3.2 presents the case where random shocks to the nominal exchange rate and the non-traded good price level are considered.

In the case of a CP regime, the central bank sets a rate of devaluation for the domestic currency and the natural log of the nominal exchange rate at each point in time, E_t^{CP}, is determined by:

$$E_t^{CP} = \overline{E} + a^{CP} t \tag{4}$$

where $\overline{E}$ denotes the initial value for the nominal exchange rate and a^{CP} corresponds in this case to the rate of devaluation set by the central bank, and t simply represents time.

Under this framework the path that the overall price level, P_t^{CP}, will follow is determined by substituting (4) in (3'),

$$P_t^{CP} = \overline{E} + a^{CP}t + (1-\rho)(1-\gamma)[P_{t-1}^{H} - E_{t-1}] \qquad (5)$$

When the central bank is implementing IT, the natural log of the overall price level, P_t^{IT}, at each point in time is determined by:

$$P_t^{IT} = \overline{P} + a^{IT}t \qquad (6)$$

where $\overline{P}$ denotes the initial value for the overall price level and a^{IT} denotes the rate at which the overall price level increases, in other words the inflation target[11]. Substituting P_t in expression (3') with expression (6) and isolating the nominal exchange rate results in the following expression for the path of the nominal exchange rate, E_t^{IT}, under IT,

$$E_t^{IT} = \overline{P} + a^{IT}t - (1-\rho)(1-\gamma)[P_{t-1}^{H} - E_{t-1}] \qquad (7)$$

The nominal exchange rate *should* follow this path in order to comply with the inflation target, given the inflation target and the dynamics of the non-traded good inflation. After an exogenous shock causes a sudden change in the nominal exchange rate, and therefore a misalignment of the real exchange rate, a central bank committed to IT is forced to manage, directly (intervention in the foreign exchange market) or indirectly (interest rate management), the nominal exchange rate according to expression (7), as in Flood and Jeane (2000) and Drazen (2001). By doing so, the central bank offsets inflationary pressure caused by the catching up effect of the non-traded good price level with lower depreciation rates for the domestic currency (lower inflation for the traded good)[12]. These interventions have been characterized as "Fear of Floating" practices given that under IT the nominal exchange rate is supposed to be a flexible exchange rate. Nevertheless, as it is mentioned by Jonas and Mishkin (2003), Ball and Reyes (2004), and Schmidt-Hebbel and Werner (2002), these fear of floating practices are justified under IT, have been observed, can be identified in the data, and have been officially documented[13].

The central bank of Brazil, which adopted IT in 1998 – 1999, openly intervened in the foreign exchange rate market directly in 2001 by selling six billion US dollars during the year[14]. The central bank of Chile, which adopted IT in 1991, publicly announced that in order to reduce nominal exchange rate volatility it would sell 1.5 billion US dollars in the foreign exchange rate market (FOREX) in the middle of 2001 and would issue three billion US dollars in dollar-denominated peso bank debt to provide a hedge against future depreciation[15]. Mexico's central bank adopted IT in 1997 – 1999 and had in place a formal scheme to accumulate reserves during 1996 – 2001. Also a contingent dollar sale mechanism, which was enacted when the peso depreciated heavily during one day, was introduced and actively utilized from January 1997 to June 2001. The total sales through this scheme were for two billion US dollars[16].

Although these direct or indirect interventions in the foreign exchange market are similar to those suggested by Goldstein (2002) for a "Managed Floating Plus" regime, in this case they are not motivated by the desire of central banks to reduce or discourage currency mismatches of assets and liabilities in the financial sector. They are needed to offset the non-traded good inflation rate in such a way that the combination of the depreciation rate, which represents the traded goods inflation, and the non-traded goods inflation rate results in the overall inflation target.

With the price determination framework introduced above it is possible to show that a sudden increase in the nominal exchange rate results in a higher pass-through effect under CP than under IT. The initial nominal exchange rate movement (increase or decrease) can be the result of an exogenous shock under both regimes. For example, an increase in the world interest rate. Under a CP regime there would be an outflow of foreign reserves as capital flows into foreign instruments that offer higher returns. These circumstances could reduce the amount of international reserves to levels at which the crawling peg regime would not be sustainable. Therefore the monetary authority decides to devalue the domestic currency in order to avoid the consequences of running out of foreign reserves.

An increase of the world interest rate under IT has similar results. Initially the domestic currency would depreciate and the central bank, committed to the IT regime, would intervene directly or indirectly in the foreign exchange rate market in order to adjust the exchange rate according to Equation (7)[17].

For the comparison of the pass-through effect under CP and IT, it can be assumed that there are two countries that are exactly the same in every respect except for their monetary regime. One implements CP while the other employs IT, but the IT-country sets the inflation target equal to the devaluation rate set by the CP-country (i.e. $a^{IT} = a^{CP} = a$)[18]. Furthermore, and without loss of generality, the initial values for the nominal exchange rate, the non-traded good price level, and the overall price level are all set equal to one. Then the pass-through effect under each regime, resulting from an unexpected exchange rate movement, can be determined, at every point in time, by calculating the ratios between the overall price level and the nominal exchange rate,

$$r_t^1 = \frac{P_t^{CP}}{E_t^{CP}} = \frac{\overline{E} + at + (1-\rho)(1-\gamma)[P_{t-1}^H - E_{t-1}]}{\overline{E} + at} \tag{8}$$

$$r_t^2 = \frac{P_t^{IT}}{E_t^{IT}} = \frac{\overline{P} + at}{\overline{P} + at - (1-\rho)(1-\gamma)[P_{t-1}^H - E_{t-1}]} \tag{9}$$

Expression (8), r_t^1, denotes the ratio between the overall price level and the nominal exchange rate for the CP regime, while expression (9), r_t^2 denotes the corresponding one for the IT regime. These ratios measure the proportion of the overall price level relative to the nominal exchange rate level at every point in time and both of them are equal to one in steady state. Once a shock takes place, the two ratios can be compared at every point in time thereafter in order to see which overall price level has approached the level of the nominal exchange rate faster. The regime for which the ratio approaches one faster is the one that has the highest pass-through effect from exchange rate movements into inflation. In other words, this regime would be the one in which changes of the nominal exchange rate are translated faster into changes in the overall price level.

Letting R_t be equal to r_t^1 / r_t^2, and α denote the initial increase in the nominal exchange rate, resulting from an exogenous shock that takes place at time τ, then if the pass-through effect is greater under CP than under IT, it should follow that $R_t \geq 1$ for every $t > \tau$[19]. Appendix 1 shows that under this simple (no uncertainty) framework this is always the case since

$$\frac{\alpha}{[E_{t-1} - P_{t-1}^H]} \geq (1-\gamma) \tag{10}$$

holds for every $t > \tau$. This analytical conclusion matches the empirical results of various studies discussed in Section 1, but the reasoning is completely different. The possibility of a high pass-through effect, under IT, forces the direct or indirect intervention of the central bank in the foreign exchange rate market. These actions will guarantee that the exchange rate follows the path that is consistent with the inflation target. If the central bank does not intervene directly or indirectly in the foreign exchange market, the overall inflation rate will be above the target rate because the inflationary pressure from domestic prices is not being offset by lower rates of depreciation of the domestic currency (meaning lower inflation of tradable goods).

When a central bank does intervene, the overall inflation rate will be in line with the target but the data will show that the relationship between inflation and depreciation is weaker. In other words, sudden increases/decreases of the nominal exchange rate are not permitted to translate into higher/lower inflation rates. Therefore it is possible to argue, to some extent, that the lower pass-through effects observed in emerging economies that adopted IT can be the result of central bank interventions in the foreign exchange market that have been observed, can be identified in the data, have been officially documented, and are consistent with the inflation target. If this is so, then lower pass-through effects are not entirely explained by the degree of credibility of the central bank, output gaps, the inflation environment within the country, and/or the industry composition of a country's import bundle. The direct or indirect interventions of an IT central bank, i.e. justified fear of floating practices, can also explain the declines observed recently. Following this logic it is possible to conclude that the pass-through effect is still high under IT, but the data will not show it since the effects are being reduced by the central bank actions.

It is important to emphasize that these results hold not only under the assumption that $a^{IT} = a^{CP} = a$. The proof presented in the Appendix shows that if $a^{IT} \neq a^{CP}$ the pass-through effect under the CP is greater than under IT, i.e. $R \geq 1$, as long as the following condition holds:

$$(a^{CP} - a^{IT})t \geq (1-\rho)[(1-\gamma)(E_{t-1} - P^{H}_{t-1}) - \alpha] \qquad (11)$$

The right hand side of equation (11) is always negative, since the maximum difference between the nominal exchange rate and the non-traded good price level is equal to α. Additionally, it is reasonable to assume that a^{CP} and a^{IT} are both greater or equal to zero. Therefore for any case where $a^{CP} \geq a^{IT}$ the results hold. It is also possible to show that for the case $a^{CP} - a^{IT} < 0$ there is a critical value for the difference between a^{CP} and a^{IT} beyond which the pass-through under IT is greater than that observed under CP at all times. Finally, for values of this difference that lie between the critical value and zero, R_t is greater than one for a period of time after the shock occurs, eventually falls below one and ultimately approaches one[20].

Using inflation and exchange rate data for Brazil, Chile, and Mexico, it possible to classify the case where $a^{CP} < a^{IT}$ as unlikely. The average overall twelve-months inflation rates during the IT regime for Brazil (1999 – 2004), Chile (1999 – 2004), and Mexico (1999 – 2004) have been 8.07 %, 2.84 % and 7.76 %, respectively. While the twelve-months domestic currency depreciation rates during the CP regime have been 8.39 % for Brazil (1995 – 1998), 5.51 % for Chile (1991 – 1998), and 6.65 % for Mexico (1989 – 1994). Comparing these rates, across regimes, it is possible to conclude that, statistically, for the cases of Brazil and Mexico $a^{IT} = a^{CP} = a$, while for Chile $a^{CP} > a^{IT}$[21]. For simplicity, throughout the study the discussion is based on the results obtained using the assumption of $a^{IT} = a^{CP} = a$.

The following section presents simulations that employ the price determination framework discussed above to illustrate that when there is a regime switch, from CP to IT, lower pass-through effects, as defined and analyzed in the empirical literature, are the natural result of justified interventions under IT.

3. Simulations for the Pass-through Effect Analysis

3.1 Magnitude Analysis

The two graphs in Figure 1 present simulated data, based on the framework presented above, for the nominal exchange rate, the non-traded good price level, and the overall price level[22]. The graph on the left shows the simulated data for a country that implements CP while the one on the right shows it for one implementing IT. The vertical dotted lines in both graphs represent time τ. Before $t = \tau$ the rates of change for all the variables are the same for both regimes, in other words both countries are in steady state. At $t = \tau$ an exogenous shock (for example an increase in the world interest rate) forces an increase in the nominal exchange rate, assumed to be the same for both countries. The overall price level also increases to a level determined by the share of the traded-good price in the overall price index, and, finally, the non-traded good price remains at the original level since it responds sluggishly, in other words it can not increase immediately. In order to visualize if the pass-through effect is greater in one of the regimes, Figure 2 graphs the results for $R_t = r_t^1 / r_t^2$.

[Insert Figure 1 Here]

Figure 2 indicates that a lower pass-through effect is observed under IT since $R_t \geq 1$. Appendix 1 shows that, for this simple (non-stochastic) case, this result always holds and explains that the magnitude of the difference between the pass-through effects of both regimes depends on the share of traded goods in the overall price level, the degree of the non-traded goods price sluggishness and the magnitude of the effect of the initial shock on the nominal exchange rate. The higher the share of the traded good in the overall price level, the lower is the difference in pass-through effect between the two regimes. The degree of the sluggishness of the non-traded good affects the speed at which both pass-through effects converge to one. A faster convergence occurs if the non-traded good price is less sluggish. Finally, the greater the initial change in the nominal exchange rate the greater will be the pass-through effect under the CP regime with respect to that of the IT regime.

[Insert Figure 2 Here]

Another way of showing the magnitude of the difference between the pass-through effects observed under each regime is by looking at the ratio between the accumulated overall inflation and the accumulated depreciation over a certain period of time. Define r_t^1* as the ratio between accumulated inflation and accumulated depreciation for the CP regime, while r_t^2* denotes the corresponding ratio for the IT case. Then, if $R_t^* = (r_t^1*)/(r_t^2*) > 1$, it is possible to conclude that the pass-through effect under CP is greater than the one observed under IT. Figure 2 depicts the results for R_t^* obtained from the simulated data presented in Figure 1. These results show that the pass-through effect under CP can be considerably higher, almost twelve % higher at some point, than the pass-through observed under IT. If the share of the traded good price is reduced from 0.5 to 0.4, the pass-through effect under CP is almost twenty % higher than under IT[23].

This simulation shows, under the assumption of having the same exchange rate shock for both regimes, that the pass-through effect is greater under CP than under IT. However the depreciation rates observed in the data, for Brazil, Chile and Mexico, under a CP regime and under IT do not present a clear pattern of magnitude. The average (and maximum) yearly depreciation rates observed under the CP regime in these countries were 8.39 (16.69), 5.51 (17.54) and 6.65 (15.90) %, respectively, while under IT these were 18.46 (69.79), 5.18 (24.70), and 3.87 (23.60) %[24]. These rates have to be considered when drawing conclusions regarding the extent to which the pass-through effect is an issue for a given country.

3.2 Nominal Exchange Rate and Non-traded Good Price Shocks

The simple (non-stochastic) framework presented above can be modified in order to allow some variation within the regimes, as well as shocks originating from the non-traded good sector. Monetary authorities sometimes announce range targets for inflation, instead of point targets, and some countries use crawling peg regimes under which the rate of devaluation is set to be around a given mean. For these cases it is possible to do a stochastic simulation under which both countries are hit by an exogenous shock that forces a depreciation of the domestic currency, under IT, and a devaluation, under CP, above or below the expected rates. For the CP it is possible consider the case where the rate of devaluation, denoted by a^{CP} in expression (4), is normally distributed with mean,

$\bar{a}^{CP}$, equal to the set devaluation rate and standard deviation equal to σ_{CP}. For the IT regime, the randomness can be introduced by including a normally distributed random term in the expression that determines the path that the nominal exchange rate should follow in order to comply with the inflation target. Finally, in order to account for price shocks originating in the non-traded good sector, a normally distributed random term, v_t, with zero mean and standard deviation equal to σ_{PH}, is introduced in the determination of the non-traded good price level, expression (2)[25]. The resulting expression is

$$P_t^H = P_{t-1}^H + (E_t^e - E_{t-1}) + \gamma(E_{t-1} - P_{t-1}^H) + v_t \tag{12}$$

After substituting for P_t^H in expression (1') with expression (11), and recalling that $E_t^e = \bar{E} + \bar{a}^{CP} t$, results in the following expression for the overall price level under a crawling peg regime,

$$P_t^{CP} = \bar{E} + \bar{a}^{CP} t + \rho[E_t - (\bar{E} + \bar{a}^{CP} t)] + (1-\rho)(1-\gamma)(P_{t-1}^H - E_{t-1}) + (1-\rho)v_t \tag{13}$$

where E_t denotes the realized nominal exchange rate at time *t*. It is straight forward to see that the expected level for the overall price level (i.e. using the expectations operator on expression (13)) is equal to the level observed for the non-stochastic case, expression (5)[26], and that any deviation from the expected exchange rate results in an unexpected increase of the overall price level equal to $\rho[E_t - (\bar{E} + \bar{a}^{CP} t)]$. Similarly, any unexpected shocks of the non-traded good sector translate into an increase of the overall price level equal to $(1-\rho)v_t$ Regarding the IT case, the path that the nominal exchange rate should follow in order to comply with the inflation target is a function of the inflation target, the expected non-traded good price level, and a random shock. Using equation (6) and the expected value of expression (11) to substitute for P_t^{IT} and P_t^H in equation (1'), respectively, isolating the nominal exchange rate, E_t, and adding the random term results in the path that the value of foreign currency in terms of domestic currency will follow under IT,

$$E_t^{IT} = \frac{\overline{P} + a^{IT}t - (1-\rho)E_t^e - (1-\rho)(1-\gamma)(P_{t-1}^H - E_{t-1})}{\rho} + \psi_t \qquad (14)$$

where ψ_t denotes a normally distributed random term, with mean zero and variance equal to σ_{IT}. Given that under IT the monetary authority does not intervene directly in the exchange rate market (i.e. it does not fix the exchange rate) there is some room for deviations from the optimal path (due to the lagged effect of policy actions and/or unforeseen frictions/distortions in the market). Using the expectations operator on expression (14) it can be shown that the expected path for the nominal exchange rate, under IT, matches that of the non-stochastic case, expression (7).

Even though no formal proof is presented here, the simulation discussed in this section shows how the same framework used for the non-stochastic case can be applied here for the study of the pass-through effect. For the following simulation the target rates for the domestic currency devaluation, under CP, and the inflation rate, under IT, are each six %, and σ_{CP}, σ_{IT}, and σ_{PH} are set equal to 1.0, 3.5 and 0.5 %, respectively[27]. At time $t = \tau$ an exogenous shock causes an increase of forty % in the nominal exchange rate, well above the expected rate. The simulated data for this exercise and the results for R_t and R_t^* are presented in Figures 3 and 4.

[Insert Figures 3 and 4 Here]

For the most part the results match those presented for the non-stochastic case, but there are two differences that should be noted. First, under this (stochastic) framework the transition paths are not smooth and the ratio of levels, R_t , oscillates around one before the exogenous shock takes place and after the greater part of this shock has been assimilated by the non-trade good price level (i.e. after the non-traded good price level has caught up with the traded good price level). Second, the magnitude of the variance of the random term, v_t , introduced for the determination of the non-traded good price level is not trivial. Intuitively, if the overall inflation dynamics of a country are determined almost entirely or predominantly by random shocks originating in the non-traded good sector, then the relevance of exchange rate shocks (i.e. the pass-through effect) on the non-traded good inflation rate, and consequently on the overall inflation rate, diminishes as σ_{PH} increases.

Figure 5 presents a simulation of the unlikely case where σ_{PH} is set equal to 5.0 %, value that substantially exceeds the variability of the domestic currency devaluation, under CP, and that of the depreciation rate, under IT. Not surprisingly the results show that the ratio R_t, which compares the pass-through effect between CP and IT, has no trend or specific pattern. The reason for this is that one of the determinants for R_t being greater or equal (very close) to one depends on the difference between the accumulated shocks of the nominal exchange rate and the non-traded good price level. When the variance of the non-traded good shock exceeds that of the nominal exchange rate shock, then the summation of the non-traded good price shocks can easily and quickly exceed that of the traded good price shocks. This is an unlikely case because in practice shocks to the non-traded good price level are usually smaller and less frequent than exchange rate shocks[28].

[Insert Figure 5 Here]

These results suggest that as long as the magnitude of the non-traded good price shocks is sufficiently small, it can be shown that the pass-through effect from currency depreciation into inflation is greater under CP than under IT.

3.3 Correlation Analysis between Inflation and Depreciation

Schmidt-Hebbel and Werner (2002) and Garcia and Restrepo (2001), among others, have shown that lower correlation coefficients between the exchange rate and the inflation rate have been observed recently in emerging economies and argue that this is evidence of lower pass-through effects[29]. Schmidt- Hebbel and Werner (2002) report that the correlation coefficient between the overall inflation rate and the rate of currency depreciation for Chile went from 0.37 (1990 – 1994) to -0.72 (1995 – 1998), for Brazil the coefficient fell from 1.0 (1995 – 1998) to -0.16 (1999 – 2001), and for Mexico the correlation coefficient remained practically constant over the period considered in their study (0.66 for 1995 – 1998 and 0.67 for 1999 – 2001)[30]. Even though the empirical results, in general, point towards a lower correlation between the overall inflation rate and the rate of domestic currency depreciation, very few have argued that this result might be linked to the adoption of IT[31]. The stochastic framework discussed above can be used to explore the possibility of this, lower pass-through effect, being a side-effect of the direct or indirect interventions in the foreign exchange rate market that take place under IT[32].

The correlation coefficients between inflation and domestic currency depreciation for the simulated data presented in Figure 3 are 0.90 for the CP regime, and 0.98 for IT. These results suggest that if the magnitude of the correlation coefficient is used to characterize the degree of the pass-through effect, as in Garcia and Restrepo (2001) and Schmidt – Hebbel and Werner (2002), there are no differences between the pass-through effect under IT and CP. But a different picture is obtained when the model is modified slightly in order to resemble reality a bit better[33].

Countries that announce targets for their inflation rates are not expected to meet them exactly. Instead, it is expected that the realized rate should not be consistently above or below the target and a clear trend towards the point target should persist. In other words, a gradual approach towards the target, with some fluctuations, is considered normal. As support of this argument, Figure 6 shows the realized inflation rate and the inflation target for Brazil, Chile, the Czech Republic, Korea, Mexico and Poland, all of these countries adopted IT during the late nineties. The graphs in Figure 6 show that the realized inflation target oscillates around the target and when large deviations are observed a gradual approach towards the target is observed. Introducing the assumption about gradual inflation targeting into the analytical inflation framework presented above changes the correlation results and shows that under IT the linear relationship between inflation and exchange rate is weaker.

[Insert Figure 6 Here]

In order to introduce the assumption of gradual inflation targeting, it is assumed that the central bank uses the following ad-hoc adjustment rule. For the cases where inflationary/deflationary pressure arises from a sudden increase/decrease of the nominal exchange rate in response to an exogenous shock like an increase/decrease in the world interest rate or a negative/positive money demand shock, the overall inflation rate will be allowed to be above/below the target for a certain period of time. The difference between the realized inflation rate and the target (inflation gap) will decrease as the system returns to the steady state. Initially, the expected gap allowed is determined by $2e^{1-(1+i)/\mu}$. Where μ is greater or equal to one and represents a magnitude adjustment parameter, as it increases/decreases the initial allowed gap between the realized inflation and target increases/decreases as well. i denotes the number of periods since the initial shock took place, and as this number increases the difference between the allowed inflation rate and the point target decreases[34].

The following simulation considers several unexpected jumps (up/down) in the nominal exchange rate. The periods and actual magnitude of the nominal exchange rate increases/decreases are determined randomly but it is assumed that initially the central bank implements CP and after the fifth unexpected increase occurs, at t = τ, a regime switch takes place and IT is adopted[35, 36].

Figure 7 presents the inflation rate and the domestic currency devaluation/deprecation rate for the simulated data, while Table 1 shows the results for the correlation analysis. Before time τ the system is under the CP regime described above and afterwards it is under the gradual IT regime. For this simulation the mean devaluation under CP and the mean inflation target under IT were both set at 6.0 %, μ was set equal to two, and the rest of the parameter values were the same as in the previous simulations. Setting μ equal to two results in an expected initial inflation gap close to 3.3 %, gap that seems to be in line with the realized inflation gap observed in the graphs presented in Figure 6. It is very clear that the linear relationship between inflation and depreciation rate is lower under IT [37, 38].

[Insert Figure 7 and Table 1 Here]

The decrease in correlation is due to the fact that when the shock takes place, under IT, the depreciation rate and the overall inflation rate are moving in opposite directions. For example, when an exogenous shock forces a higher than expected depreciation of the domestic currency the overall inflation rate will be higher than the depreciation rate, but it will be decreasing towards the steady state level, while the depreciation rate is lower than the overall inflation rate, but it will be increasing towards the steady state level[39]. It should be noted that the longer the inflation rate is allowed to be above/below the target and/or the greater is the initially allowed inflation gap (i.e. the higher μ is) the lower the correlation coefficient will be between the inflation and depreciation rates, since this would translate into a longer transition period towards steady state.

With the introduction of gradual inflation target, a regime that is widely used by IT central banks, it is possible to show that lower correlation coefficients between the overall inflation rate and the domestic currency depreciation rate, observed recently in countries like Brazil, Chile and Mexico, can be associated with the adoption of IT and the abandonment of crawling peg regimes. Finally the results obtained through the correlation analysis do not change when different rates for the inflation rate, under IT, and for the rate of depreciation, under the CP regime, are considered (i.e. $a^{IT} \neq a^{CP}$).

4. Conclusions

Recently the literature has shown that the nominal exchange rate pass-through effect into inflation has been decreasing for several emerging economies. Some studies have analyzed the cases of emerging countries that recently abandoned a fixed exchange rate regime or a CP and adopted IT and argue that the reasons behind the declining pass-through effects include negative output gaps, stronger credibility of the central bank's commitment towards achieving low inflation rates, lower inflation environments, and/or changes in the industry composition of a country's import bundle. This study shows that, keeping other relevant factors constant, declining pass-through effects can be the result of changes in monetary policy regimes, specifically a switch from a CP regime to an IT regime. By establishing a clear relationship between the lower pass-through and the adoption of IT, this analysis offers an additional explanation for the declining pass-through effect of currency depreciation on domestic inflation observed recently in countries like Brazil, Chile, and Mexico.

The lower pass-through effects coincide with the adoption of IT in these countries and these declining effects are the result of direct or indirect interventions of the central bank in the foreign exchange market. The monetary authorities intervene in response to higher/lower than expected exchange rate movements, caused by exogenous shocks, as they try to comply with the inflation target. These interventions, justified under IT, result in lower/higher rates of currency depreciation that compensate inflationary/deflationary pressure arising from the non–traded good sector. This situation translates into lower correlation coefficients between domestic currency depreciation and the overall inflation rate (lower pass–through) with respect to those observed under a CP regime. This is an empirical result reported in the literature and replicated by the simulations of the theoretical framework presented here.

Finally, given the low pass–through levels observed recently, previous studies have argued that the nominal exchange rate effects on the overall inflation rate may no longer be an issue for emerging economies implementing IT. This paper suggests that the central bank interventions (observed and documented) in these economies is sufficient evidence to contradict this argument. The pass-through effect is still relevant and therefore the monetary authorities are forced to intervene in the foreign exchange rate market in order to comply with their inflation target. The pass-through effect is still high under IT, but the data will not reveal this since the effects are being reduced by the central bank actions. In order to address the desirability of the CP and IT regimes, future work should consider the analysis of the welfare implications of these policy actions. For example, measures based on output and/or inflation gaps (or volatilities) could be used for the comparison of the regimes.

Appendix

Proposition: After the nominal exchange rate increases by α, in response to an exogenous shock, the pass-through effect under a crawling peg is always greater or equal to the pass-through effect under IT if $a^{CP} \geq a^{IT}$.

Proof: In order for this proposition to be true, R_t must be greater or equal to 1 when $a^{CP} \geq a^{IT}$.

$$R_t = \frac{r_t^1}{r_t^2} \geq 1 \qquad \text{(A1)}$$

where $r_t^1 = P_t^{CP} / E_t^{CP}$, while $r_t^2 = P_t^{IT} / E_t^{IT}$.

Under the CP regime the overall price level is determined by expression (3'), here rewritten for exposition purposes as (A2)

$$P_t^{CP} = E_t^{CP} + (1-\rho)(1-\gamma)[P_{t-1}^H - E_{t-1}] \qquad \text{(A2)}$$

where the nominal exchange rate, E_t^{CP}, is determined by expression (4), and P_t^H, ρ, and γ represent the domestic price level for the non-traded good, the proportion of the traded goods in the overall price level, and the rate of adjustment of the non-traded good price level to misalignments of the real exchange rate, respectively.

Under IT the nominal exchange rate is determined by

$$E_t^{IT} = P_t^{IT} - (1-\rho)(1-\gamma)[P_{t-1}^H - E_{t-1}] \qquad \text{(A3)}$$

where the overall price level, P_t^{IT}, is determined by expression (6) . Rewriting (A1) as

$$r_1 \geq r_2$$

and plugging in (A2) and (A3) for P_t^{CP} and E_t^{IT}, respectively, results in the following expression.

$$\frac{E_t^{CP} + (1-\rho)(1-\gamma)[P_{t-1}^{H} - E_{t-1}]}{E_t^{CP}} \geq \frac{P_t^{IT}}{P_t^{IT} - (1-\rho)(1-\gamma)[P_{t-1}^{H} - E_{t-1}]} \qquad \text{(A4)}$$

which can be simplified to

$$1 + \frac{(1-\rho)(1-\gamma)[P_{t-1}^{H} - E_{t-1}]}{E_t^{CP}} \geq \frac{P_t^{IT}}{P_t^{IT} - (1-\rho)(1-\gamma)[P_{t-1}^{H} - E_{t-1}]}$$

$$1 - \frac{P_t^{IT}}{P_t^{IT} + (1-\rho)(1-\gamma)[E_{t-1} - P_{t-1}^{H}]} \geq \frac{(1-\rho)(1-\gamma)[E_{t-1} - P_{t-1}^{H}]}{E_t^{CP}}$$

$$\frac{(1-\rho)(1-\gamma)[E_{t-1} - P_{t-1}^{H}]}{P_t^{IT} + (1-\rho)(1-\gamma)[E_{t-1} - P_{t-1}^{H}]} \geq \frac{(1-\rho)(1-\gamma)[E_{t-1} - P_{t-1}^{H}]}{E_t^{CP}}$$

$$E_t^{CP} \geq P_t^{IT} + (1-\rho)(1-\gamma)[E_{t-1} - P_{t-1}^{H}] \qquad \text{(A5)}$$

If a shock of magnitude α takes place at time $t = 0$, then expressions (4) and (6) (i.e., the paths of the nominal exchange rate under CP and that of the overall price level under IT, respectively) determine that at time $t > 0$ the value for the nominal exchange rate under CP and the overall price level under IT would be:

$$E_t^{CP} = \overline{E} + a^{CP}t + \alpha \quad \text{and} \quad P_t^{IT} = \overline{P} + a^{IT}t + \rho\alpha \,.$$

where $\overline{E}$ and $\overline{P}$ denote the initial values for the nominal exchange rate and the overall price level, respectively, and are both set equal to one[40].

Plugging these expressions in (A5) results in the following

$$\overline{E} + a^{CP}t \quad + \alpha \geq \overline{P} + a^{IT}t + \rho\alpha + (1-\rho)(1-\gamma)[E_{t-1} - P_{t-1}^{H}] \qquad \text{(A6)}$$

therefore $R_t = \frac{r_t^1}{r_t^2} \geq 1$ if

$$(a^{CP} - a^{IT})t \geq (1-\rho)\left[(1-\gamma)(E_{t-1} - P_{t-1}^{H}) - \alpha\right] \qquad \text{(A7)}$$

For the case where $a^{CP} = a^{IT} = a$, then (A7) becomes

$$\frac{\alpha}{[E_{t-1} - P_{t-1}^{h}]} \geq (1-\gamma) \qquad \text{(A8)}$$

The difference between the ratios depends on ρ, γ, and the magnitude of the effect of the exogenous shock on the nominal exchange rate, α. If ρ, the proportion of the traded goods in the overall price level, is equal to one, then from expression (A4) it is possible to show that both ratios are equal to one since the adjustment of the overall price index would be equal to the change of the traded good price index. When $0 \leq \rho < 1$, then the ratio will depend on the speed of adjustment of the non-traded good price index towards real exchange rate misalignments, γ. If $\gamma = 0$, then $r_t^1 = r_t^2$ because the difference between the nominal exchange rate and the overall price level, after the shock, will always be equal to α for both regimes. This corresponds to the improbable case where the non-traded goods price level does not react to real exchange rate misalignments, therefore central bank implementing IT does not need to counteract inflationary pressure arising from real exchange rate misalignments. When $\gamma = 1$, the non-traded good price level reacts instantaneously and therefore $r_t^1 = r_t^2 = 1$. Finally, when $0 < \gamma < 1$ the pass-through effect under the CP, r_t^1, will always be greater than the one observed under IT, r_t^2, since the maximum difference between the nominal exchange rate and the non-traded good is equal to α. This difference is observed at time $t = \tau$ and it decreases thereafter. Therefore the left hand side of (A8) will always be greater or equal to one, while the right hand side will be less than or equal to one.

For the case where $a^{CP} \geq a^{IT}$, then it is possible to show that if the shock takes place at time t = 0, then expression (A7) shows that $R_t = \frac{r_t^1}{r_t^2} \geq 1$ for all t. This is simply because the right hand side of equation (A7) is always negative, given that the maximum difference between the nominal exchange rate and the non-traded good price level is equal to α. Expression (A7) also implies that for the case where $a^{CP} - a^{IT} < 0$ there exists a critical value such that if the difference is below this value (i.e., is more negative) then $R_t = \frac{r_t^1}{r_t^2} \leq 1$ for all t. Additionally, for the values of this difference that lie between the critical value and zero, when the shock takes place at t = 0, $R_t = \frac{r_t^1}{r_t^2} \geq 1$ for a period of time, afterwards becomes less than one, and ultimately approaches one.

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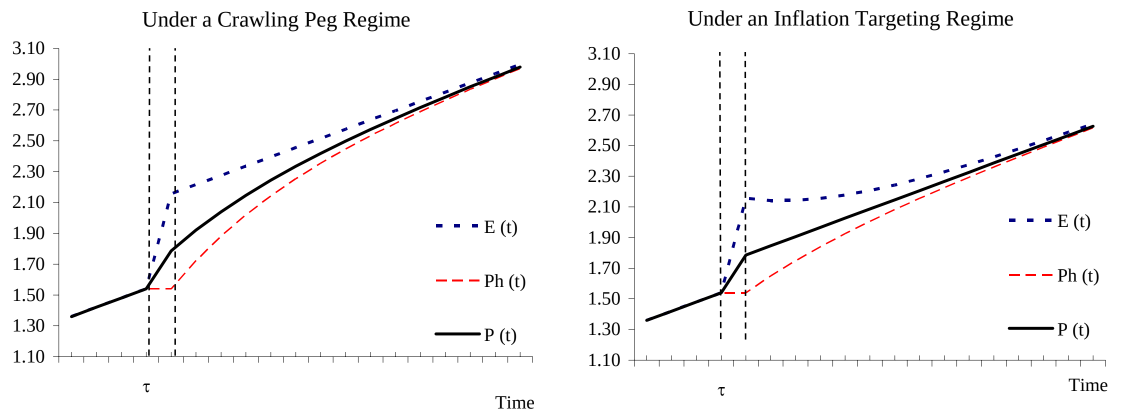

Figure 1. Simulated Data for the Nominal Exchange Rate (E), Non-Traded Good Price Level (Ph), and Overall Price Level (P).

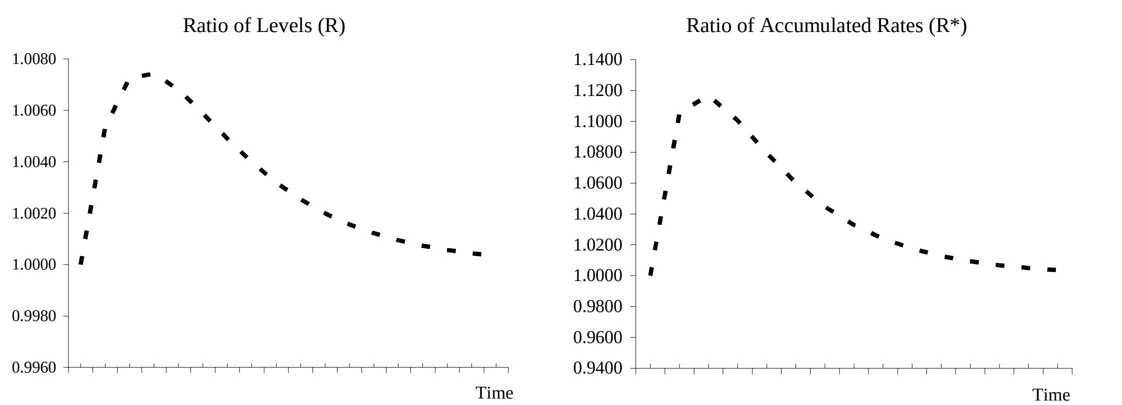

Figure 2. Ratio between the Pass-Through Effect under a Crawling Peg and the Pass-through Effect under an Inflation Targeting Regime.

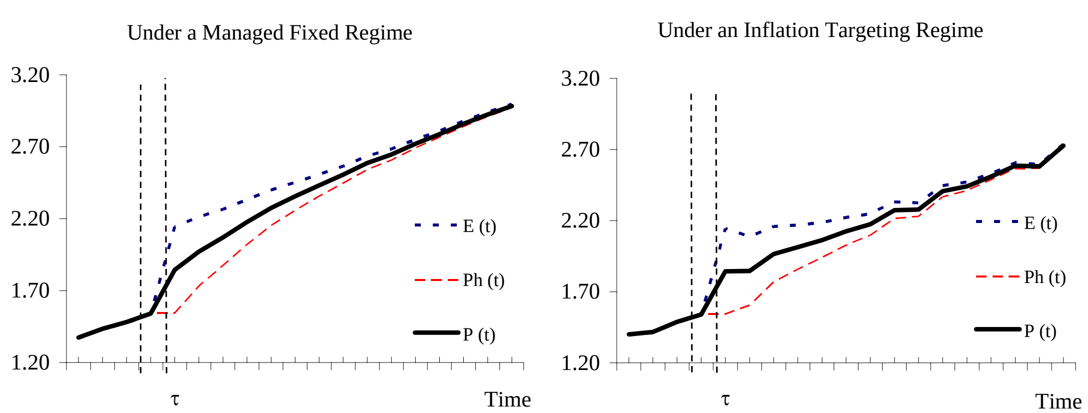

Figure 3. Stochastic Simulated Data for the Nominal Exchange Rate (E), Non-Traded Good Price Level (Ph), and Overall Price Level (P).

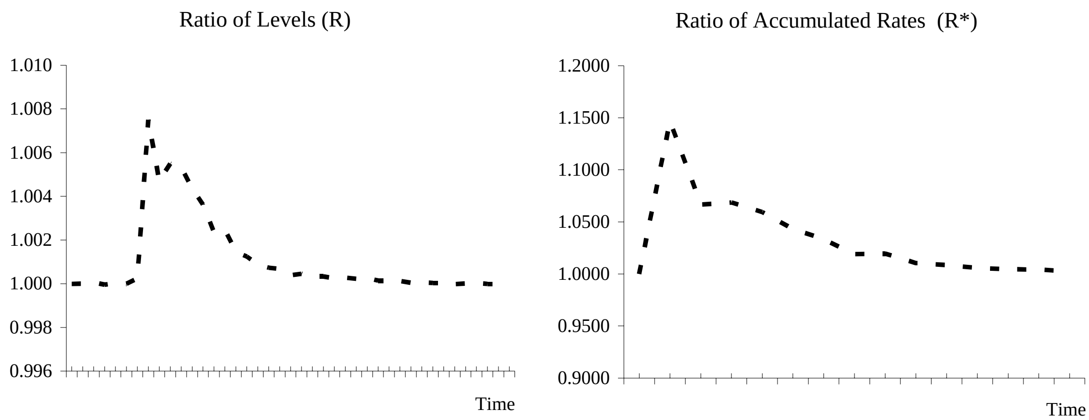

Figure 4. Ratio between the Pass-Through Effect under a Crawling Peg and the Pass-through Effect under an Inflation Targeting Regime for the Stochastic Case.

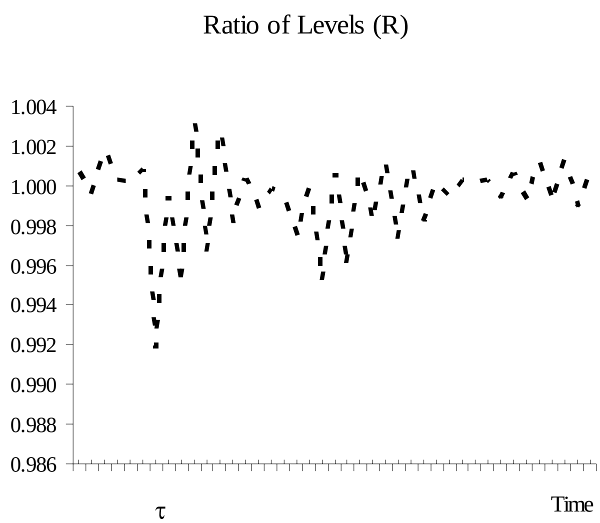

Figure 5. Ratio between the Pass-Through Effect under a Crawling Peg and the Pass-through Effect under an Inflation Targeting Regime for the "Unlikely" Stochastic Case where σ_{PH} (5%) is greater than σ_{FE} (1.0%) and σ_{IT} (3.0%).

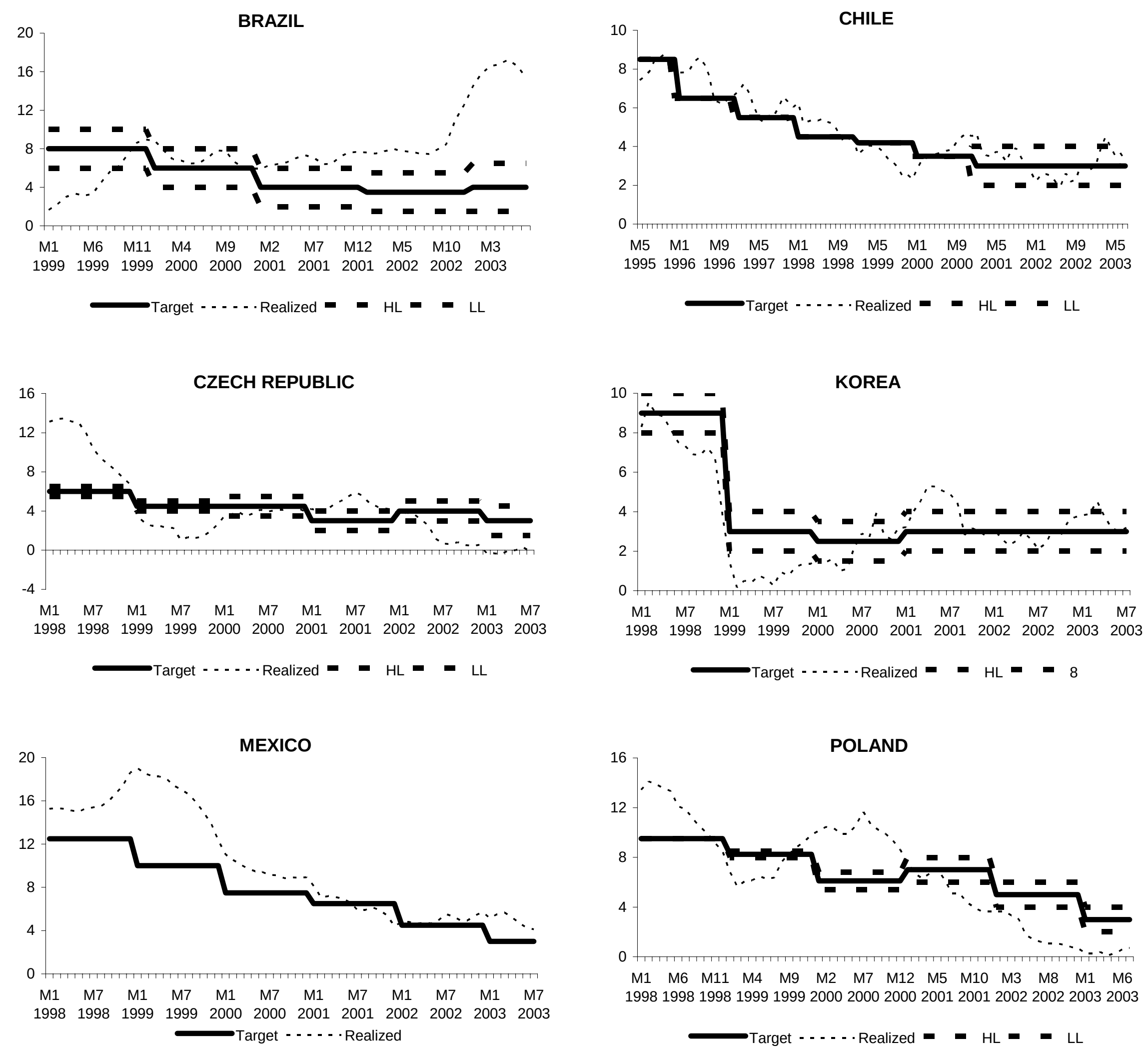

Figure 6. Realized Inflation rates vs. Inflation Targets (HL and LL denote high limit and lower limit for countries announcing a range for the inflation target)

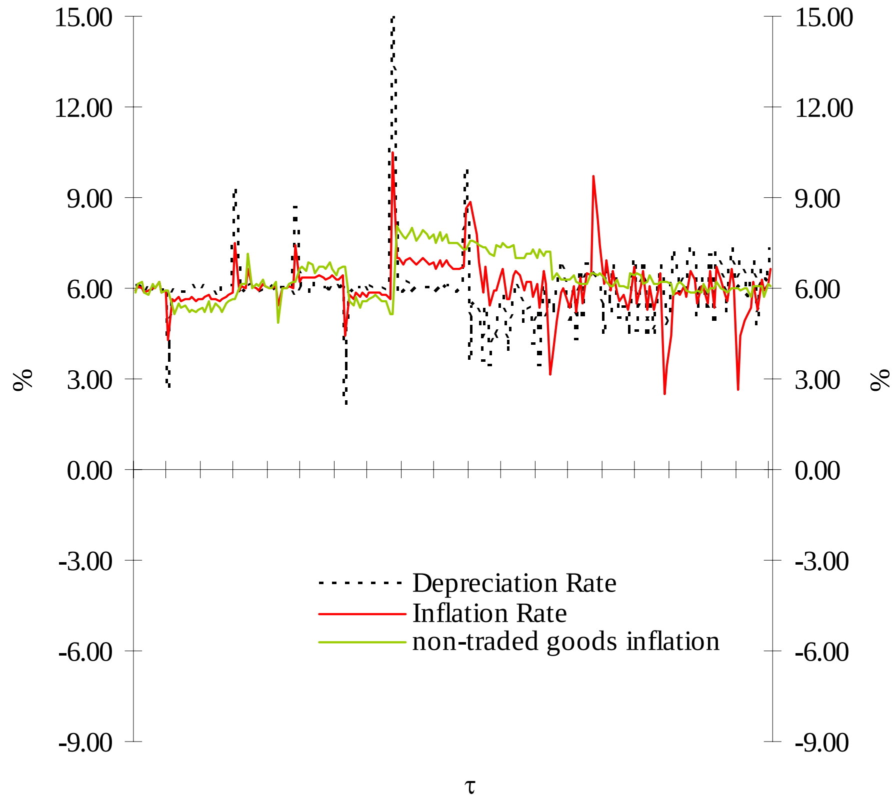

Figure 7. Stochastic Simulated Data for the Inflation Rate and the Domestic Currency Depreciation Rate (data used for the correlation analysis)

	CP Regime Period	Regime Switch Period (from CP to IT)	IT Regime Period
	τ - 100 ≤ t ≤ τ	τ - 50 ≤ t ≤ τ + *50*	τ < t ≤ τ + *100*
100 periods Rolling Window Correlation Coefficient	0.80	0.56	0.26
	τ - 50 ≤ t ≤ τ	τ - 25 ≤ t ≤ τ + *25*	τ < t ≤ τ + *50*
50 Periods Rolling Window Correlation Coefficient	0.84	0.63	0.27

Table 1. Rolling Windows Correlation between Inflation and Domestic Currency Depreciation (data from Figure 7.)

[1] For an excellent introduction to Inflation Targeting in emerging economies refer to Masson, Savastano and Sharma (1997), and Mishkin (2000).

[2] It is important to clarify the specific pass-through effect considered for this study. Throughout the paper the term pass-through refers to the effects of exchange rate changes into *domestic inflation (consumer prices)*, along the lines of the study by Gagnon and Ihrig (2004). In the literature there are other studies, for example Campa and Goldberg (2002) and to some extent Corsetti and Pesenti (2002), that have focused on the analysis of the exchange rate pass-through into *import* prices.

[3] Schmidt-Hebbel and Werner (2002) argue that the lower pass-through from exchange rate changes into domestic inflation observed in Brazil and Chile, after these countries adopted IT, suggest that exchange rate movements should be of much less of a concern now for policymakers in these countries than in the past. They emphasize that lower pass-through effects could provide a rationale for the relatively weak reaction of monetary policy to exchange rate movements —at least for that part that reflects inflationary pressures.

[4] Gagnon and Ihrig (2004) note that a natural extension of their paper would be the inclusion of developing countries in the analysis.

[5] The term "fear of floating" was introduced by Calvo and Reinhart (2002) and Reinhart (2000). It refers to the usage of the interest rate to affect (indirectly) the nominal exchange rate, more so than International Reserves, by central banks that claim to have a flexible exchange rate policy regime. Given that under an IT regime the nominal exchange rate is supposed to float freely, the interventions observed under IT might be

classified as Fear of Floating, even though these are justified. Ball and Reyes (2004) show that Calvo and Reinhart's (2002) metric to classify countries as either fear of floaters, fixers (fixed exchange rate regimes), or floaters (flexible exchange rate regimes) can actually lead inflation targeting (IT) regimes to be misclassified as fear of floaters.

[6] It is possible to analyze the pass-through effect by using a general equilibrium model that introduces firms, individuals, the government, and financial markets. But as Kumhof (2001) and Auernheimer and George (2000) show, the dynamics for the overall consumer price index, the nominal exchange rate, and the price of non-traded goods are determined by the evolution of the real exchange rate and therefore coincide with those presented here. Therefore such a complete analysis would not add to the results of this study.

[7] From this point forward all expressions are in lognormal forms.

[8] The sluggish response of the non-traded good mirrors the resulting price stickiness that would be obtained with the forward-looking sticky price model of non-traded goods by Calvo (1983) and the modified version of this framework presented in Kumhof (2000). The specification used here follows the one presented in Auernheimer and George (2000).

[9] Corsetti and Pesenti (2002) refer to this equilibrium as the "Optimal Float". They present an alternative equilibrium where a fixed exchange rate *(currency union) is fully credible*. In this case they argue that exporters would not follow the law of one price, in fact they would follow a policy of local currency pricing.

[10] Brook et. al. (2003) point out that the natural classification of exchange rate regimes divides de facto regimes into five "coarse" categories—fixed, limited flexibility,

managed floating, freely floating, and freely falling. In this study the crawling peg regime encompasses, to some extent, the first three of these categories.

[11] These assumptions correspond to a strict IT regime. Later in the paper this framework is modified in order to analyze flexible IT regimes.

[12]Goldfajn and Valdes (1999) have shown that under this framework, if the currency depreciation is just enough to correct an overvaluation of the currency, then it would not translate into inflationary pressure. But currency depreciation that is not based on required adjustments of relative prices (real exchange rate) would induce inflation or would reverse itself (through nominal appreciation). Borensztein and De Gregorio (1999) have shown that usually the end result of large depreciations not based on correction of relative prices do indeed translate into inflationary pressure.

[13] The nominal exchange rate control that the monetary authority exercises under IT during the transition to the steady state is the reason why Calvo (2000) and others have noted that IT and managed floating are undistinguishable. Kumhof (2001) has shown that the central bank can use the interest rate or the international reserves to maintain the nominal exchange rate at the level that is consistent with the inflation target.

[14] Annual Report of 2001, Banco Central do Brasil.

[15] Monetary Report of 2001, Banco Central de Chile. Initially the central bank of Chile also maintained an exchange rate target policy that started in 1984 and lasted until 1999

[16] Most of these sales took place in 1998. Further discussion on this contingent scheme can be found in Werner (1997), Milo and Werner (1998), Banco de Mexico (1998), and Banco de Mexico (1999)

[17] It could be argued that under perfect foresight, the nominal exchange rate would move to its long-run equilibrium level since the market knows that the central bank will intervene in order to avoid inflationary pressure from the nominal exchange rate. Under the current framework, and even if perfect foresight is assumed, the exchange rate does not follow this dynamic equilibrium path because of the frictions introduced by the non-traded goods price stickiness.

[18] If the countries are the same in every respect but their monetary policy regime, then their steady state rates of inflation for traded and non-traded goods are exactly the same but the dynamics towards the steady state are different. The specific reasons for presenting the case where the $a^{IT} = a^{CP} = a$, as well as the implications of the equality not holding, are discussed in detail later in the paper.

[19] It should be noted that the initial movement of the nominal exchange rate is assumed to be the same for both regimes for exploratory purposes. This does not mean that exogenous shocks (like changes in the world interest rate) *should* have the exact same effect on the nominal exchange rate (and other variables) for both regimes. The objective of this study is not that of assessing the degree of vulnerability, nor desirability, of any given regime. The paper focuses on the study of the magnitude differences of the pass-through effect observed across the two regimes considered. To do this, the regime specific dynamics are compared for the same initial exchange rate movement.

[20] If the shock takes place at time $t = 0$ then $R_t \leq 1$, for all t, if $(a^{CP} - a^{IT}) < -\alpha(1-\rho)\gamma$. This follows because at $t = 1$, $E_{t-1} - P^{H}_{t-1} = \alpha$.

[21] These conclusion are based on *t-tests* results. The number of observations (and the standard deviations) for the inflation targets are 74 (3.52) for Brazil, 74 (1.18) for Chile,

and 73 (4.44) for Mexico. For the depreciation rate during the CP regime are 43 (2.88), 96 (6.6), and 71 (5.04). The *p-values* for the *t-tests* are 0.29 for Brazil, 0.0001 for Chile, and 0.08 for Mexico. Twelve month rates are used because they are more reliable estimates, as opposed to monthly or quarterly rates, for the target rates under each regime. The classification of CP and IT, as well as the time periods for each regime follow those reported by Calvo and Reinhart (2002). The only modification is the time period considered for Brazil's crawling peg regime. The period considered is 1995 – 1998 instead of 1994 – 1998. The sample is reduced in order to avoid the hyperinflation lived in Brazil throughout the early nineties.

[22] The corresponding values for the parameters of the simulation are 0.20 for the parameter that determines the degree of sluggishness of the non-traded good price, γ, 0.50 for the share of the traded good in the overall price index, ρ, and an initial shock to the nominal exchange rate of 40 %. For the inflation target the central bank sets a target of six % for the overall inflation rate, while in the case of the crawling peg regime the central banks sets a rate of devaluation of six %. The results are robust across different values for these parameters. The share of the traded good was set to 0.50 following De Gregorio, Giovannini and Wolf (1994) but, as it is discussed in Appendix 1, the results hold for all possible values for ρ and the other parameters.

[23] Given the parameters chosen for the simulation, in order for $R<1$for all t the critical value for the difference between the inflation target, under IT, and the depreciation rate, under CP, is approximately equal to -0.04 (four %). It is approximately because log differences are being used.

[24] Using the same sample periods discussed above for the CP and the IT regimes. The standard deviations for the average yearly depreciation rates (%) observed under the CP regime were 2.88, 6.68, and 5.04 for Brazil, Chile, and Mexico, respectively. The standard deviations under IT were 25.03, 10.61, and 7.19, respectively.

[25] The case considered here corresponds to that where the non-traded price shocks are the same for both regimes, CP and IT. Another possibility, not pursued here, is to consider different non-traded price shocks for each regime.

[26] Recalling that $a^{CP} = \overline{a}^{CP}$, $E(E_t) = \overline{E} + \overline{a}^{CP} t = E^e$, and $E(v_t) = 0$.

[27] The nice result of modeling the fixed regime in this way is that the real exchange rate will tend to be around steady state. The reason for setting the standard deviation of the rate of devaluation under CP lower than the one set for IT, is simply because under CP the variability of the rate of change of the nominal exchange rate should be lower in theory, and it is in practice, than that observed under IT, where the nominal exchange rate is flexible. The chosen values for the standard deviation of the nominal exchange rate under CP and IT are based on the observed standard deviations for the Brazilian, Chilean, and Mexican exchange rate data (calculated using official central bank data available online). For Brazil the standard deviation for the monthly rate of change, in percentages, of the nominal exchange rate under the CP regime (1995 – 1998) was 0.30, Chile's has been 1.47 (1991 – 1998), while for Mexico (1989 – 1994) it was close to 0.9. During their IT regimes, Brazil's standard deviation (1999 – 2004) has been 5.9, Chile's (1999 – 2004) has been 2.51, and Mexico's (1999 – 2004) has been 1.8. The numbers in the simulation are simply an approximation to the average of the observed standard deviations. But the results presented in this study hold for different set of values. Further

discussion regarding the magnitude of the variation of the non-traded good sector is presented later in the paper.

[28] This argument is a byproduct of the literature focused on the study of relative prices and the real exchange rate. For further discussion see Engel (1993) and Betts and Kehoe (2001).

[29] Gagnon and Ihrig (2004) have shown similar results, lower correlation coefficients between inflation and exchange rate changes, for industrial economies after they adopted IT or increased the emphasis on inflation stabilization.

[30] Chile gradually adopted an IT regime in the early nineties, Brazil adopted (fully) IT at the end of 1999, and Mexico adopted IT (officially) in 1999. All of these countries had some sort of CP regime before they adopted IT.

[31] Gagnon and Ihrig (2004) suggest that the adoption of IT could explain the lower explanatory power of the domestic currency depreciation in explaining the overall inflation process.

[32] The stochastic framework is used since variations in the data are needed in order to perform a correlation analysis with the simulations.

[33] The general result obtained in the previous simulations does not change when the slight modifications discussed in this section are introduced into the price determination framework.

[34] The graphs presented in Figure 5 show that the gradual inflation targeting is much slower than the one assumed here, but if the results hold for a much faster adjustment mechanism, then they would be strengthened for a much slower one.

[35] The computer is asked to choose ten numbers between 1- 100, without repetition, in order to determine the periods in which a shock occurs. Afterwards the computer selects the magnitude of the shock from the range (-16, 16), which would correspond to a maximum 10 % decrease/increase above the expected rate of change (six %) for the nominal exchange rate.

[36] One of the reasons why a regime switch is considered is because this scenario was observed in many emerging countries in the mid nineties. But another reason is that the simulation allows for the analysis of the correlation coefficient under a CP regime for $t < \tau$, under IT for $t > \tau$, and for a transition period in between the two regimes.

[37] Rolling windows correlation coefficients were computed following Garcia and Restrepo (2001) and Schmidt-Hebbel and Werner (2002).

[38] In some of the simulations, not presented here for matters of space, the correlation coefficient between the inflation and depreciation rates is negative for the IT regime. If the magnitude parameter μ is increased to three, then the results of negative correlation coefficients from the simulations are a lot more frequent. This result matches that presented in the empirical analysis by Garcia and Restrepo (2001), and Schmidt – Hebbel and Werner (2002) for the cases of Brazil and Chile.

[39] This is the result of the central bank enforcing the path that the nominal exchange rate should follow, expression (13), in order to meet the overall inflation target.

[40] It is important to note that, at the time of the shock, the overall price level under IT increases only to a level determined by the share of the traded-good price in the overall price index (i.e., $\alpha\rho$)